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PROCEEDINGS
OF THE
TWENTY-NINTH ANNUAL MEETING

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PART I.
COMMITTEE REPORTS
NEW AND REVISED TENTATIVE STANDARDS
LIST OF STANDARDS AND TENTATIVE STANDARDS

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SUMMARY OF THE PROCEEDINGS OF THE TWENTY-NINTH ANNUAL MEETING

ATLANTIC CITY, N. J., JUNE 21–25, 1926

The TWENTY-NINTH ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at the Chalfonte-Haddon Hall, Atlantic City, N. J., June 21–25, 1926. The following is an analysis of the attendance at the meeting: Members in attendance or represented, 792; guests, 113; total, 905; ladies, 239. The corresponding statistics for the Twenty-eighth Annual Meeting are: Members in attendance or represented, 775; guests, 93; total, 868; ladies, 250.

FIRST SESSION—TUESDAY, JUNE 22, 2 P. M.

On Wrought Iron, Cast Iron and Magnetic Testing

President W. H. Fulweiler in the chair.

The minutes of the Twenty-eighth Annual Meeting were approved as printed.

The report of Committee A-2 on Wrought Iron was presented by the chairman, H. J. Force. On recommendation of the committee, revisions of the Standard Specifications for Staybolt, Engine-Bolt and Extra Refined Wrought-Iron Bars (A 84 – 24), the Standard Specifications for Merchant Bar Iron (A 85 – 24) and of the Standard Definitions of Terms Relating to Wrought-Iron Specifications (A 81 – 21) were accepted for publication as tentative, the revisions of the definitions being changed somewhat from the form in which they had been preprinted, so as to omit reference to the definition for Common Iron and to recommend the omission of the definition for Merchant Bar Iron.

The report of the committee was, on motion, adopted.

A paper entitled "A Study of the Relation Between Properties of Cast-Iron Pipe Tested Under Impact, Internal Pressure and Flexure and the Corresponding Properties Found in Several Kinds of Test Specimens Taken Therefrom," by Arthur N. Talbot and Frank E. Richart, was presented by Mr. Talbot and discussed.

A paper entitled "A Note on the Relations Between the Proposed Standard Test Bar for Cast Iron and the Two Existing Standards," by J. T. MacKenzie, was presented by the author.

The report of Committee A-6 on Magnetic Properties was presented by the chairman, Thomas Spooner. The tentative revisions of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 24), submitted as complete new tentative methods, were accepted for publication as tentative. On motion, the report of the committee was adopted.

The report of Committee A-8 on Magnetic Analysis was presented by the chairman, F. P. Fahy. The report reviewed the work that had been done since the organization of the committee, leading to the development of methods of magnetic analysis. The recent work had been confined to an investigation in connection with high-speed steel, which was reported upon in a paper appended to the report, entitled "Magnetic Analysis of High Speed Steel," by Thomas Spooner. Upon the adoption of the report Mr. Fahy called upon Mr. Spooner to present the paper.

A paper by Haakon Styri entitled "Testing of Ball-Bearing Races by Electric and Magnetic Methods," was presented by the author. This paper and the report of Committee A-8 were then discussed jointly, Mr. Fahy calling upon a number of the members of Committee A-8 to report upon the particular investigations they had in hand.

The report of the committee of tellers, consisting of H. S. Rawdon and R. L. Sanford, appointed to canvass the letter ballot on election of officers, was received. The tellers reported that 1170 legal ballots had been cast, the votes being as follows:

For President, to serve for one year: J. H. Gibboney, 1170 votes.

For Vice-President, to serve for two years: G. W. Thompson, 1170 votes.

For Members of Executive Committee, to serve for two years:

Cloyd M. Chapman, 1170 votes.
W. F. Edwards, 1168 votes.
W. B. Price, 1169 votes.
H. T. Shelley, 1169 votes.

In accordance with the ballot the Chair declared the officers, listed above, elected.

The chairman then requested the Past-Presidents, A. N. Talbot and A. A. Stevenson, to escort the President-elect to the chair. The President-elect, J. H. Gibboney, expressed his appreciation of the honor of his election to the Presidency. He called attention to the important place that the Society was taking, serving practically all the industries of the country, and pledged his efforts to advance the work of the Society to render an even larger and more acceptable service to the engineering profession.

The Vice-President-Elect, G. W. Thompson, was then escorted to the chair by Past-Presidents Talbot and Stevenson. He thanked the members for the honor bestowed upon him and pledged his best efforts to the newly elected President and the Society in carrying out the administrative duties.

The meeting then adjourned till 8 P. M.

SECOND SESSION—TUESDAY, JUNE 22, 8 P. M.

Presidential Address, Reports of Administrative Committees and Testing

Past-President George K. Burgess in the chair.

The chairman introduced President W. H. Fulweiler, who presented the presidential address, choosing as his topic "The Importance of Little Things in the Standardization of Methods of Testing."

The secretary presented the annual report of the Executive Committee which discussed membership activities, the work of standing committees, publications, finances and administrative matters relating to committee activities and relations with other societies.

In the Executive Committee report are given the names of the members who have died during the past year. One of those who had died recently was Past-President Guilliaem Aertsen. The following minute was adopted by a standing and silent vote:

GUILLIAEM AERTSEN

1855 - 1926

The American Society for Testing Materials, assembled in its Twenty-ninth Annual Meeting, records with deep sorrow the death, on April 20, 1926, of its honored and beloved Past-President Guilliaem Aertsen. Mr. Aertsen's health failed during the closing days of his Presidency of the Society in 1924. Late in that year he suffered a stroke which confined him to his home, and in his weakened condition he was unable to recover from a sudden relapse a few days before his death.

Practically his entire life was spent in the steel industry. He entered the employ of the Midvale Steel Co. in 1876 and in the next eleven years of his connection with that company, finally as Superintendent of Works, he laid the foundation for his extensive fund of knowledge of steel manufacture, his understanding of men and his executive ability. He was successively connected with the Homestead Steel Co. as Superintendent, the Latrobe Steel Co. as Manager, the Midvale Steel Co. as Consulting Engineer, the Midvale Steel and Ordnance

Co. as Engineer and Auditor, and the Bethlehem Steel Co., staying with the latter until his last illness.

His profound knowledge of the metallurgy of steel, especially of steel products for railroads, made him sought-after by the various technical societies of his calling, and he was a member of many of them.

The American Society for Testing Materials owes a great debt to Guilliaem Aertsen for his whole-hearted services in its behalf. On the technical side, he was long an active member of the Committee on Steel, serving for a time as its Vice-Chairman, and of the Committee on Heat Treatment of Iron and Steel. On the executive side he was a member of the Executive Committee from 1918 to 1920, Vice-President from 1921 to 1923 and President in 1923–24. He served during the difficult period occasioned by the death of Edgar Marburg in 1918 and the subsequent establishment of independent Society headquarters. As chairman of the Finance Committee in those days he was largely responsible for the financial policy and it was principally through his efforts that the Society headquarters were established at the Engineers' Club of Philadelphia. His clear thinking and wise counsel were invaluable. In every way the Society has benefited and been honored by his membership.

But even more than these outstanding services to the Society will we remember Aertsen the man: his sterling character, his kindly sympathetic manner,—interested always in his fellow men,—his charming personality. We mourn his loss even as we appreciate the privilege of having known him.

The heartfelt sympathy of the Society is extended to his family.

The report of the Executive Committee contained a number of recommendations relative to the publication of the Book of Standards in two parts rather than one as heretofore. Part I would contain the specifications dealing with metals and Part II those dealing with non-metals. Each member would be furnished either Part I or Part II of the Book of Standards by virtue of his membership and a member desiring the other part could obtain it upon the payment of an additional charge of $2.00. Upon motion, these recommendations were approved.

The report further emphasized the needs for additional income to cover the ever-increasing publication requirements, the promotion of research and the corresponding increase in office personnel. To meet these needs the Executive Committee recommended (1) the establishment of a Fund to which annual contributions will be accepted from the industries and (2) the establishment of an entrance fee of $10.00 for members and $5.00 for junior members and a transfer fee from one grade of membership to another equal to the difference in entrance fees. These recommendations were approved.

The recommendation concerning entrance and transfer fees, as well as a further recommendation that a class of student membership be established, involved the revision of the By-laws, and the amendments proposed by the Executive Committee covering these matters in Article I, Sections 1, 2 and 4 and in Article VII, Sections 1 and 2, were accepted and referred to letter ballot of the membership of the Society.

On motion, the report of the Executive Committee was adopted.

The President announced on behalf of the committee in charge of raising the fund for the Marburg Lecture and Dudley Medal that $4500 had been secured by popular subscription. The industries had since been approached and to date the fund totaled approximately $7000. A number of the members of the committee had not yet been heard from, but from the assurances that the committee had already received, the committee felt justified in announcing that it had been successful in completely raising the fund.

The report of Committee E-9 on Correlation of Research, discussing briefly the work of the committee during the year and reviewing the various research projects being carried on by the Society's committees and through joint activities, was presented by the chairman, H. F. Moore. On motion, the report of the committee was adopted.

The report of Committee E-6 on Papers and Publications was presented by the chairman, C. L. Warwick. On motion, the report of the committee was adopted.

The report of Committee E-1 on Methods of Testing was presented by the chairman, J. A. Capp. On recommendation of the committee the Tentative Specifications for Sieves for Testing Purposes (E 11 - 25 T) were referred to letter ballot of the Society for adoption as standard. The chairman called on H. F. Moore to present that portion of the report dealing with the work of the Sub-Committee on Mechanical Testing. This included a report on the testing of thin sheet metals. The proposed revisions of the Tentative Methods of Verification of Testing Machines by Means of an Elastic Calibration Bar (E 4 – 24 T) were accepted, the methods being continued as tentative. On motion, the report of the committee was adopted.

A paper entitled "Effects of Size and Shape of Test Specimen on the Tensile Properties of Sheet Metals," by R. L. Templin, and one entitled "A New Type of Mirror Extensometer," by M. F. Sayre, were presented by the authors and discussed.

A paper entitled "A New Twist Meter for Torsion Tests," by J. H. Smith, was presented by the author.

A paper entitled "Can the Hardness of Materials Be Neglected in Granulometric Sieve Analysis?" by H. P. Hollnagel and E. A. Harty, was presented by title.

The meeting adjourned till the following morning.

THIRD SESSION, WEDNESDAY, JUNE 23, 9.30 A. M.

On Steel

(Held Simultaneously with the Fourth Session)

Vice-President J. H. Gibboney in the chair.

The report of Committee A-1 on Steel was presented by the chairman, F. M. Waring. The report as preprinted submitted proposed Tentative Specifications for Marine Boiler Steel Plates. These specifications were withdrawn by the committee. The proposed revisions of the Standard Specifications for Carbon-Steel Rails (A 1 – 24), for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 – 24), and for Steel Track Spikes (A 65 – 24), presented as complete specifications, were accepted for publication as tentative. The proposed revisions of the Standard Specifications for Carbon-Steel Bars for Railway Springs (A 14 – 16), for Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 – 18), for Carbon-Steel Bars for Vehicle and Automobile Springs (A 58 – 16), for Silico-Manganese-Steel Bars for Automobile and Railway Springs (A 59 – 16), for Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (A 60 – 16), for Welded and Seamless Steel Pipes (A 53 – 24), for Boiler and Firebox Steel for Stationary Service (A 70 – 24), and for Elliptical Steel Springs for Automobiles (A 69 – 18), recommended by the committee, were accepted for publication as tentative.

The Tentative Specifications for Carbon Tool Steel (A 71 – 24 T), the Tentative Specifications for High-Speed Tool Steel (A 92 – 24 T) and for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 25 T) were referred to letter ballot revised as recommended by the committee.

The proposed revisions of the Tentative Specifications for Steel Tie Plates (A 67 – 20 T) and for Carbon-Steel Castings for Valves, Flanges, and Fittings for High-Temperature Service (A 95 – 25 T), recommended by the committee, were accepted, the specifications being continued as tentative.

The following proposed specifications submitted by the committee were accepted for publication as tentative:

Tentative Specifications for:

Commercial-Quality Hot-Rolled Bar Steels;
Commercial Cold-Finished Bar Steels and Cold-Finished Shafting;
Cold-Rolled Strip Steel;
Forged or Rolled Steel Pipe Flanges for High-Temperature Service;
Lap-Welded and Seamless Steel Pipe for High-Temperature Service.

On motion, the report of the committee was adopted.

The report of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel was presented by the chairman, G. K. Burgess. On motion, the report of the committee was received.

The following five papers were presented:

"The Cause and Prevention of Embrittlement of Boiler Plate," by S. W. Parr and F. G. Straub—presented by Mr. Parr and discussed;
"Methods of Test in Relation to Flow in Steels at Various Temperatures," by H. J. French—presented by the author and discussed;
"Compressive Strength and Deformation of Structural Steel and Cast-Iron Shapes at Temperatures up to 950° C.," by S. H. Ingberg and P. D. Sale—presented by Mr. Sale;
"Some Defects Which Have Been Found in Large Carbon-Vanadium Forgings—Their Causes and Prevention," by O. B. Schultz—presented by the author;
"Strength of Welded Joints," by J. R. Dawson—presented by the author and discussed.

The meeting adjourned till 4 P. M.

FOURTH SESSION, WEDNESDAY, JUNE 23, 9.30 A. M.

On Brick, Tile, Refractories and Fire Tests

(Held Simultaneously with the Third Session)

Past-President F. M. Farmer in the chair.

The report of Committee C-8 on Refractories was presented by the chairman, W. H. Fulweiler. The proposed revisions in the Standard Definitions for Clay Refractories (C 27 – 20) were accepted for publication as tentative as recommended by the committee. The revisions of the Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action (C 38 – 21 T), recommended by the committee, were accepted, the method being continued as tentative. The chairman presented Specifications for Clay Fire Brick for Malleable Furnaces with Removable Bungs and for Annealing Oven and asked leave to have these printed in the Proceedings as information with the report of the committee. The chairman then called on Mr. Booze to present a paper prepared by him entitled "A Study of the Spalling Test for Fire-Clay Brick," submitted as an appendix to the report.

On motion, the report of the committee was adopted.

The report of Committee C-10 was presented by the chairman, S. H. Ingberg. The Tentative Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile (C 34 – 24 T) were recommended to be revised and advanced to standard in their proposed revised form. The revisions suggested included the addition of an informative note covering the best criterion to be used in determining weather resistance. On motion, it was voted to eliminate this informative note. It was further voted to change the mean compressive strength requirement for hard tile from 1800 to 2000 lb. per sq. in. and for soft tile from 1200 to 1000 lb. per sq. in. These changes in strength requirements gave a slightly greater latitude in the classifications and were recommended on the basis of new information that had become available through tests made at the U. S. Bureau of Standards. This change, together with the informative note mentioned above, were acceptable to the committee. The specifications were then approved for reference to letter ballot for adoption as standard in their revised form.

The proposed revisions in the Tentative Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile (C 56 – 24 T) and for Hollow Burned-Clay Floor Tile (C 57 – 24 T) were accepted as recommended by the committee, the specifications being continued as tentative. On motion, the report was adopted.

The report of Committee C-3 on Brick in the absence of the chairman, T. R. Lawson, was presented by the vice-chairman, H. T. Shelley. In presenting the report Mr. Shelley stated that although not mentioned in the report the committee had given consideration to a definition for brick and of a regional modification to be inserted in the brick specification. On motion, the report was adopted.

The report of Committee C-5 on Fireproofing was presented by the chairman, I. H. Woolson. The proposed Tentative Specifications for Fire Tests of Building Construction and Materials (C 19 – 26 T) were accepted for publication as tentative to replace the Standard Specifications for Fire Tests of Materials and Construction (C 19 - 18). On motion, the report was adopted.

The work of revising the Specifications for Fire Tests had been carried out in a Sectional Committee on Fire Tests of Materials and Construction functioning under the rules of procedure of the American Engineering Standards Committee and organized under the sponsorship of the A.S.T.M., the U. S. Bureau of Standards and the Fire Protection Group, the personnel of the sectional committee being almost identical with the personnel of Committee C-5. Mr. Woolson was also chairman of this sectional committee and proceeded to present the report of the sectional committee to its sponsor bodies. In doing so, he recommended that the specifications be referred to the American Engineering Standards Committee at the discretion of the president and secretary.

On motion, the report was received.

The report of Committee C-6 on Drain Tile was presented by the chairman, Anson Marston. On motion, the report of the committee was adopted.

A paper entitled "Determination of Pressure Distribution on Circular Pipe When Tested in the A.S.T.M. Standard Sand Bearings," by D. G. Miller and P. C. McGrew, was presented by F. C. Lang and discussed.

The meeting adjourned till 4 P. M.

FIFTH SESSION—WEDNESDAY, JUNE 23, 4 P. M.

Edgar Marburg Lecture

President W. H. Fulweiler in the chair.

The President in opening the session explained the institution of the Edgar Marburg Lectures, their object being to bring to the Society, men of especial distinction in various branches of engineering to the end that the members might learn of the latest developments in the knowledge of materials and of testing. The lecture was in commemoration of Dr. Edgar Marburg who had been the first secretary of the Society and who had been associated with its predecessor, the American Section of the International Association for Testing Materials. He then introduced the lecturer, Prof. Arthur Newell Talbot, who chose for the subject of his lecture "Research and Reinforced Concrete as an Engineering Material."

Professor Talbot reviewed the development of knowledge through tests and experimental study in the field of reinforced concrete in this country, calling attention to the virtual absence of scientific knowledge relative to reinforced concrete in this country twenty-five years ago as contrasted with the considerable development of the study in Europe. He then presented a statement of the multitude of questions confronting the Joint Committee on Concrete and Reinforced Concrete when it was organized in 1904. The significant subjects and items of research growing out of this unexplored condition were then reviewed, and some of the main results of a new study of concrete in compression, carried out at the University of Illinois, were mentioned, and the desirability of research in cement was stressed.

At the conclusion of the lecture, Mrs. Marburg expressed her appreciation of the honor accorded to her husband's memory. In doing so she mentioned the enthusiasm Dr. Marburg had displayed concerning the activities of the Society and how the Society had come to be an intimate in their every-day life. She appreciated particularly that the Society should wish to keep with it the something of himself that Edgar Marburg had bequeathed to the Society.

The meeting then adjourned till the following morning.

SIXTH SESSION—THURSDAY, JUNE 24, 9.30 A. M.

On Corrosion and Fatigue of Metals

(Held Simultaneously with the Seventh Session)

John A. Mathews in the chair.

The report of Committee A-5 on Corrosion of Iron and Steel was presented by the chairman, J. H. Gibboney. The committee submitted new Tentative Specifications for Galvanized Iron or Steel Telephone and Telegraph Line Wire and for Galvanized Iron or Steel Tie Wires. In presenting these specifications the chairman recommended on behalf of the committee that the material under Mechanical Testing of Coating appearing as Section 7 of each of the specifications be put in the form of a footnote, at the same time changing the designations Grade A, Grade B and Grade C to Type A, Type B and Type C. The specifications thus revised were accepted for publication as tentative as were the proposed Tentative Specifications for Coating of Zinc-Coated or Galvanized Wire, recommended by the committee.

On motion, the report of the committee was adopted.

The report of Committee D-14 on Screen Wire Cloth was presented by the chairman, R. W. Woodward, and was of the nature of a progress report on the exposure tests being conducted on alloy screen cloths of various composition. An appendix to the report comprising a paper by G. W. Quick entitled "Laboratory Tests on Non-Ferrous Screen Wire Cloth" was presented by Mr. Woodward. On motion, the report of the committee was adopted.

The report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys, in the absence of the chairman, E. C. Lathrop, was presented by the secretary, Sam Tour. This report comprised a statement of the progress that had been made by the committee in its cooperative tests on various types of corrosion testing. The test program at several laboratories had been completed and at still others was nearing completion. The report had not been submitted to letter ballot and on motion was adopted, subject to a subsequent letter ballot of the committee.

A paper by T. H. Nelson entitled "Recent Developments in the Use and Fabrication of Corrosion-Resistant Alloys," and one by W. H. Finkeldey entitled "Microstructure of Zinc Coatings," were presented by the authors, and discussed.

The following papers were presented by the authors and discussed jointly:

"Stress-Strain-Cycle Relationship, and Corrosion-Fatigue of Metals," by D. J. McAdam, Jr.;
"Effect of Grooves, Threads, and Corrosion Upon the Fatigue of Metals," by R. R. Moore;
"Fatigue of Metals by Direct Stress," by P. L. Irwin.

The meeting then adjourned till 8 P. M.

SEVENTH SESSION—THURSDAY, JUNE 24, 9.30 A. M.

On Road Materials, Waterproofing and Petroleum Products

(Held Simultaneously with the Sixth Session)

President W. H. Fulweiler in the chair.

The report of Committee D-8 on Bituminous Waterproofing and Roofing Materials was presented by the chairman, S. T. Wagner. The revisions of the following Tentative Specifications, recommended by the committee, were accepted, the Specifications being continued as tentative:

Tentative Specifications for Smooth-Surfaced Asphalt Roll-Roofing (D 224 - 25 T);
Tentative Specifications for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 225 - 25 T);

Tentative Specifications for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 226 - 25 T);
Tentative Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 227 - 25 T).

The committee recommended revisions of the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 - 25 T). In the report as preprinted a revision was recommended in Section 17. This revision was withdrawn. The committee added the recommendation that Section 23 of the methods be omitted. The revisions were accepted, the methods being continued as tentative. The revisions of the Tentative Methods of Testing Smooth-Surfaced Asphalt Roll-Roofing, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 228 - 25 T) were accepted as recommended by the committee, the methods being continued as tentative.

The committee submitted with its report as preprinted thirteen new specifications and two new methods of test. Of these the following were accepted for publication as tentative as recommended by the committee:

Tentative Specifications for:

Asphalt Roll-Roofing Surfaced with Granular Talc;
Heavy Weight Slate-Surfaced Asphalt, Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles;
Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs;
High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel;
High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel;
Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures;
Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures.

Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings.

The remaining specifications and method of test originally submitted with the report as preprinted were withdrawn by the committee, comprising the following specifications and method of test:

Tentative Specifications for:

Light Body Asphalt Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures;
Heavy Body Asphalt Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures;
Heavy Body Asphalt Fiber Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures;
Asphalt Fiber Cement with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures;
Heavy Body Coal-Tar Fiber Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures;
Coal-Tar Fiber Cement with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures.

Tentative Method of Test for Consistency of Bituminous Fiber Protective Coatings.

The proposed revision of the Standard Specifications for Primer for Use with Asphalt in Damp-Proofing and Waterproofing Below and Above Ground Level (D 41 – 25) was approved by a nine-tenths vote for reference to letter ballot of the Society for adoption as standard. This revision comprised a reference to the new Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings that had been accepted for publication as tentative.

On motion, the report of the committee was adopted.

The report of Committee D-4 on Road and Paving Materials was presented by the chairman, H. S. Mattimore. On recommendation of the committee the proposed revision of the Standard Method of Test for Abrasion of Road Material (D 2 – 08), comprising a change in the title, was approved by a nine-tenths vote for reference to letter ballot of the Society for adoption as standard. The proposed revisions of the Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (D 36 – 24) and of the Standard Specifications for Block for Granite Block Pavements (D 59 – 22) were approved by a nine-tenths vote for reference to letter ballot of the Society for adoption as standard. The proposed revisions of the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 18) consisting of a rewriting of the Standard Methods were accepted for publication as tentative, the new tentative method to be effective January 1, 1927.

The proposed revisions of the following tentative specifications and methods of test were accepted as recommended by the committee, the specifications and methods being continued as tentative:

Tentative Specifications for:

Asphalt Cement, 50 to 60 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 100 - 23 T);
Asphalt Cement, 60 to 70 Penetration, for Use in Sheet Asphalt, Asphaltic-Concrete and Asphalt-Macadam Pavements (D 101 - 23 T);
Asphalt Cement, 40 to 50 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 99 - 23 T).

Tentative Method of:

Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (D 70 - 20 T);
Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments (D 71 - 20 T);
Test for the Determination of Bitumen (D 4 - 23 T);
Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (D 165 - 23 T);
Test for Ductility of Bituminous Materials (D 113 - 22 T);
Test for Consistency of Portland-Cement Concrete (D 138 - 25 T).

The recommendation of the committee that the Tentative Method of Mechanical Analysis of Subgrade Soils (D 137 - 25 T) be withdrawn was approved. The following new tentative specifications and methods of test, recommended by the committee, were accepted for publication as tentative:

Tentative Specifications for Asphalt Filler for Brick Pavements (Blown Type);
Tentative Specifications for Mineral Filler for Sheet Asphalt and Bituminous-Concrete Pavements;
Tentative Method of Test for Residue of Specified Penetration;
Tentative Method of Test for Bituminous Emulsions.

The committee had submitted with its report as preprinted a Recommended Practice for Bituminous Paving Plant Inspection. This recommended practice was withdrawn by the committee. The report of the committee was on motion adopted.

A paper entitled "Effect of Size of Paving Brick on Rattler Loss," by F. H. Jackson, was presented by the author.

A paper by Prévost Hubbard and F. C. Field entitled "A Study of Certain Factors Affecting the Stability of Asphalt Paving Mixtures" was presented by Mr. Hubbard and discussed.

The report of Committee D-2 on Petroleum Products and Lubricants was presented by the vice-chairman, K. G. Mackenzie. The Tentative Method of Test for Viscosity of Petroleum Products and Lubricants (D 88 - 25 T) was approved for reference to letter ballot of the Society for adoption as standard, revised as recommended by the committee.

The proposed revisions of the following methods of test were accepted as recommended by the committee, the methods being continued as tentative:

Tentative Method of:

- Test for Penetration of Greases (D 217 - 25 T);
- Test for Analysis of Grease (D 128 - 24 T);
- Test for Sulfur in Naphthas and Illuminating Oils (D 90 - 24 T);
- Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (D 86 - 25 T);
- Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 25 T);
- Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 25 T).

The proposed new Method of Test for Burning Quality of Mineral Colza Oil and the proposed new Method for Determination of the Thermal Value of Fuel Oil were accepted for publication as tentative as recommended by the committee.

The vice-chairman then called on Mr. Flowers to outline the work of the Sub-Committee on Turbine Oils.

On motion, the report of the committee was adopted.

A paper by Winslow H. Herschel and Ronald Bulkley entitled "Measurement of Consistency as Applied to Rubber-Benzene Solutions" was presented by Mr. Herschel and discussed.

The meeting adjourned till 8 P. M.

EIGHTH SESSION—THURSDAY, JUNE 24, 8 P. M.

On Non-Ferrous Metals and Metallography

(Held Simultaneously with the Ninth and Tenth Sessions)

William Campbell in the chair.

The report of Committee B-1 on Copper Wire was presented by the chairman, J. A. Capp. The proposed revisions in the following standard specifications were accepted for publication as tentative as recommended by the committee:

Standard Specifications for:

Hard-Drawn Copper Wire (B 1 – 23);
Medium Hard-Drawn Copper Wire (B 2 – 15);
Soft or Annealed Copper Wire (B 3 – 15);
Bare Concentric-Lay Copper Cable: Hard, Medium-Hard or Soft (B 8 – 21);
Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 – 25).

The Tentative Specifications for Hot-Rolled Copper Rods for Wire Drawing (B 49 – 23 T) were approved for reference to letter ballot of the Society for advancement to standard, revised as recommended by the committee.

The proposed revisions of the Tentative Specifications for Bronze Trolley Wire (B 9 – 25 T) and for Soft Rectangular Copper Wire (B 48 – 23 T) were accepted, the specifications being continued as tentative.

On motion, the report of the committee was adopted.

The report of Committee B-4 on Metallic Materials for Electrical Heating was presented by the chairman, Dean Harvey. The proposed Tentative Method of Test for Resistivity of Metallic Materials for Electric Heating was accepted for publication as tentative. On motion, the report of the committee was adopted.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by the chairman, William Campbell, Mr. W. H. Bassett taking the chair during the presentation of the report. The proposed revisions of the Standard Methods of Chemical Analysis of Brass Ingots (B 45 – 23) and of Chemical Analysis of Brass Bearing Metals (B 46 – 23) were accepted for publication as tentative. The proposed revisions in the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 25 T) and in the Tentative Specifications for Aluminum Ingots (B 24 – 25 T), for Aluminum Sheet (B 25 – 19 T) and for Aluminum-Base Alloy Sand Castings (B 26 – 25 T) were accepted, the revisions of the Specifications B 25 – 19 T being of the nature of complete revised tentative specifications. The tentative method of test and specifications were continued as tentative in their revised form.

The following proposed new specifications were accepted for publication as tentative:

Tentative Specifications for:

Aluminum Bronze Castings;
Sand Castings of the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent;
Steam or Valve Bronze Sand Castings;
Composition Brass or Ounce Metal Sand Castings;
Aluminum-Base Sand-Casting Alloys in Ingot Form.

The Tentative Specifications for White Metal Bearing Alloys (B 23 - 18 T) and for Aluminum for Use in the Manufacture of Iron and Steel (B 37 - 20 T) were approved for reference to letter ballot for advancement to standard, as recommended by the committee.

The committee asked leave to print with its report as information proposed Specifications for Rolled Zinc.

Submitted with the report were appendices covering The Properties of High-Strength Aluminum Casting Alloys and a paper by E. R. Darby entitled "Fluidity Tests of White Metal Bearing Alloys." These were presented by title and discussion by letter was solicited. On motion, the report of the committee was adopted.

A paper by R. J. Anderson entitled "Some Mechanical Properties of Duralumin Sheet as Affected by Heat Treatment" was presented by title and discussed.

A paper by George Mortimer entitled "Aluminum Casting Alloys: The British Engineering Standards Association Specifications Reviewed" was presented by E. V. Pannell and discussed.

The report of Committee E-4 on Metallography was presented by the chairman, H. C. Boynton. The proposed revisions of the Standard Methods of Metallographic Testing of Non-Ferrous Metals (E 5 - 24) were accepted for publication as tentative as recommended by the committee.

The proposed Definition for the Term Metallography was accepted for publication as tentative to be added, when adopted, to the Standard Definitions of Terms Relating to Metallography. Similarly, the proposed Recommended Practice for the Care of the Eyes when Using a Metallographic Microscope was accepted for publication as tentative to be added, when adopted, to the present Standard Rules Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography (E 2 - 24). The proposed Recommended Practice for Radiographic Testing of Metal Castings, submitted by the committee, was accepted for publication as tentative. The chairman called on Mr. Jeffries to report upon the work of his Sub-Committee on X-ray Metallography.

Discussion was subsequently presented on certain phases of the report, principally on the paper by E. C. Groesbeck entitled "Solutions for Carbides, Etc., in Alloy Steels," submitted as an appendix to the report of the Sub-Committee on Selection and Preparation of Samples and of the report of the Sub-Committee on X-ray Metallography. On motion, the report of the committee was adopted.

A paper by E. H. Dix, Jr., and W. D. Keith entitled "Etching Characteristics of the Constituents in Commercial Aluminum Alloys" was presented by Mr. Dix and discussed.

The meeting adjourned till the following morning.

NINTH SESSION—THURSDAY, JUNE 24, 8 P. M.

On Textiles, Rubber, Coal, Timber, Insulating Materials and Slate

(Held Simultaneously with the Eighth and Tenth Sessions)

A. E. Jury in the chair.

The report of Committee D-7 on Timber was presented by the chairman, Hermann von Schrenk. The proposed Tentative Specifications for Structural Joist, Planks, Beams, Stringers and Posts, recommended by the committee, were accepted for publication as tentative. This involved the withdrawal of the Tentative Specifications for Structural Douglas Fir (D 23 – 20 T) and the withdrawal, when the Book of Standards is next published, of the Standard Specifications for Yellow-Pine Bridge and Trestle Timbers (D 10 – 15) and for Southern Yellow-Pine Timber to be Creosoted (D 24 – 20), these withdrawals being recommended by the committee and approved by the meeting. In submitting the new tentative specifications, the chairman presented a number of editorial changes that should be made, principally in Section (*D*), covering Coded Specifications for Structural Grades.

The proposed Tentative Method of Test for Distillation of Creosote Oil was accepted for publication as tentative, to replace Sections 10 to 12 of the present Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 18). On motion, the report of the committee was adopted.

The report of Committee D-13 on Textile Materials was presented by the chairman, W. F. Edwards. The proposed Tentative Specifications for Tolerances and Test Methods for Rayon and the proposed Tentative Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes, submitted by the committee, were accepted for publication as tentative. In presenting these the committee offered a number of changes of an editorial nature in the Test Methods for Electrical Silk and Cotton Tapes. The proposed new Tentative Definitions to be added to the present Tentative Definitions of Terms Relating to Textile Materials were accepted for publication as tentative. The recommendation of the committee that the Tentative Definitions be rearranged and that all definitions covering textile materials appearing in other standards and tentative standards be grouped with these tentative definitions, was approved.

The proposed General Methods of Testing Textile Fabrics, offered for publication as information with the report, were received. On motion, the report was adopted.

The report of Committee D-11 on Rubber Products, comprising a report of progress on the work of the committee on performance tests, was presented by the chairman, F. M. Farmer. On motion, the report of the committee was adopted.

The report of Committee D-5 on Coal and Coke, in the absence of the chairman, A. C. Fieldner, was presented by the secretary, W. A. Selvig. The proposed revisions of the Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 – 24), recommended by the committee, were accepted for publication as tentative.

The proposed revisions of the Tentative Method of Test for Fineness of Powdered Coal (D 197 – 24 T) were accepted as recommended by the committee, the method being continued as tentative. The proposed revised Definitions of Terms Relating to Coal and Coke were accepted for publication as tentative to replace the Tentative Definitions of Terms Relating to Coal (D 142 – 25 T) and of Terms Relating to Coke (D 121 – 24 T). On motion, the report of the committee was adopted.

The report of Committee D-9 on Electrical Insulating Materials was presented by the chairman, F. M. Farmer. The proposed revisions of the Standard Methods of Testing Molded Insulating Materials (D 48 – 24), recommended by the committee, were accepted for publication as tentative. The new Tentative Methods of Testing Electrical Insulating Oils, submitted by the committee, were accepted for publication as tentative as a revision of the Standard Methods of Testing Transformer and Switch Oils (D 117 – 24). In presenting these the committee submitted a number of changes that had developed as a result of the discussion on these methods at the meetings in connection with the Congress of the International Electrotechnical Commission.

The proposed revisions of the following tentative methods were accepted, the methods being continued as tentative:

Tentative Methods of:

Testing Insulating Varnishes (D 115 - 25 T);
Testing Electrical Porcelain (D 116 - 24 T);
Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 24 T);
Testing Untreated Insulating Paper (D 202 - 25 T);
Testing Laminated Sheet Insulating Materials (D 229 - 25 T).

An additional revision of the Tentative Methods D 115 - 24 T not appearing in the report as preprinted, was submitted to the effect that kraft paper should replace copper in the preparation of test specimens of the varnishes. This additional revision was accepted.

The proposed new Tentative Methods of Testing Insulating Materials for Resistance to Impact, and Tentative Method of Test for Surface Resistivity and Volume Resistivity of Solid Insulating Materials, recommended by the committee, were accepted for publication as tentative. On motion, the report of the committee was adopted.

A paper entitled "Impact Testing of Insulating Materials," by W. W. Werring, was presented by the author and discussed.

The report of Committee D-16 on Slate was presented by the chairman, D. W. Kessler. The proposed Definition of the Term Slate, recommended by the committee, was accepted for publication as tentative. On motion, the report was adopted.

The meeting adjourned till 8 P. M.

TENTH SESSION—THURSDAY, JUNE 24, 8 P. M.

Symposium on Rosin

(Held Simultaneously with the Eighth and Ninth Sessions)

Vice-President H. F. Moore in the chair.

The following papers entering into the Symposium on Rosin were presented by the authors, each paper being discussed when presented:

"Why a Rosin Symposium? Introduction," by F. P. Veitch;
"Rosin for Varnishes," by E. W. Fasig;
"The Use of Rosin in Insulating and Potting Compounds and in Sealing Waxes," by F. L. Roman;
"Rosin for the Floor Covering Industry," by R. B. Rohrer;
"Rosin for Soap Making," by F. J. Arthurs;
"The Use of Rosin in Printing Inks," by Louis M. Larsen (presented by Mr. Veitch);

"The Use of Rosin in the Manufacture of Core Oils," by W. R. Pate;
"The Kind of Rosin the Rosin Oil Manufacturer Wants," by Brian S. Brown;
"Rosin for the Manufacture of Sticky Fly Paper," by B. E. Kuyers (presented by Mr. Veitch);
"How Gum Rosin Is Made," by C. F. Speh;
"Wood Rosin: Its Production, Properties and Uses," by J. E. Lockwood.

The meeting adjourned till the following morning.

ELEVENTH SESSION—FRIDAY, JUNE 25, 9.30 A. M.

On Preservative Coatings and Naval Stores

(Held Simultaneously with the Twelfth Session)

K. G. Mackenzie in the chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials in the absence of the chairman, Allen Rogers, was presented by the secretary, R. L. Hallett. The following specifications and methods of test were approved for reference to letter ballot for adoption as standard as recommended by the committee:

Tentative Specifications for Bone Black (D 210 - 25 T);
Tentative Specifications for Lithopone (D 208 - 25 T);
Tentative Specifications for Lampblack (D 209 - 25 T);
Tentative Specifications for Dry Bleached Shellac (D 207 - 25 T);
Tentative Method of Test for Coarse Particles in Paint Pigments (D 185 - 24 T).

In 1925 the committee presented revisions of the Standard Specifications for Turpentine (D 13 - 24). These revisions had been modified during the year and complete new specifications entitled Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine were presented for adoption as standard to replace the present specifications. These specifications were approved for reference to letter ballot for adoption as standard. The committee recommended that in publishing these specifications the requirements and methods of test be presented in separate documents, which would make for easy reference to the methods in any other specifications for turpentine. This recommendation was approved.

The revisions of the Standard Methods of Testing Oleo-Resinous Varnishes (D 154 - 24) consisting of the addition of a new Method for Determining Elasticity of Varnishes by Means of Addition of Linseed Oil was accepted for publication as tentative. The proposed revisions of the following specifications and methods, recommended by the committee, were accepted, the specifications and methods being continued as tentative:

Tentative Specifications for Chrome Yellow (D 211 – 25 T);
Tentative Specifications for Pure Chrome Green (D 212 – 25 T);
Tentative Specifications for Reduced Chrome Green (D 213 – 25 T);
Tentative Methods of Testing Shellac Varnish (D 214 – 25 T).

In its report as preprinted the committee submitted new Specifications for Raw Linseed Oil. These specifications contemplated two grades, the requirement on iodine number on the one grade being higher than that for the other, and with certain other differences in requirements. The committee then recommended that only one grade be provided for and that the specifications be changed accordingly. This recommendation was approved, and the Specifications for Raw Linseed Oil as revised were accepted for publication as tentative to supersede when adopted the present Standard Specifications for Purity of Raw Linseed Oil from North American Seed (D 1 – 15) and to replace immediately the Tentative Specifications for Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed (D 51 – 18 T) and for Purity of Raw Linseed Oil from South American Seed (D 77 – 21 T).

The following new specifications and method of test were accepted for publication as tentative as recommended by the committee:

Tentative Specifications for Petroleum Spirits (Mineral Spirits);
Tentative Specifications for Destructively Distilled Wood Turpentine;
Tentative Specifications for Orange Shellac;
Tentative Method of Test for Specific Gravity of Pigments.

Mr. Hallett then called on Mr. Ingalls to present the work of the Sub-Committee on Physical Properties of Materials having to do with a new method for specifying color. On motion, the report of the committee was adopted.

The report of Committee D-17 on Naval Stores was presented by the chairman, F. P. Veitch. On motion, the report was adopted.

The following papers were presented and discussed:

"Hiding Power of Pigments," by R. L. Hallett—presented by the author.

"The Study of Nitrocellulose Lacquers by the Stress-Strain

Method," by G. W. Rundle and W. C. Norris—presented by Mr. Rundle.

"Mechanical Testing and Recording of the Drying of Paints and Varnishes," by J. McE. Sanderson—presented by the author.

"Accelerated Weathering: Further Developing of Apparatus and Exposure Cycles," by H. A. Nelson, F. C. Schmutz and D. L. Gamble—presented by Mr. Nelson.

The meeting adjourned till 8 P. M.

TWELFTH SESSION—FRIDAY, JUNE 25, 9.30 A. M.

On Cement, Lime, Gypsum and Nomenclature

(*Held Simultaneously with the Eleventh Session*)

George S. Webster in the chair.

The report of Committee C-1 on Cement was presented by the chairman, R. S. Greenman. The committee, in its report as preprinted, recommended proposed Specifications and Tests for Portland Cement for publication as tentative to supersede, when adopted, the present Standard Specifications and Tests for Portland Cement (C 9 - 21). The committee now presented a number of corrections and changes in the specifications consisting of the following:

Section 11.—Change to read as follows by changing the word "shall" to "may":

> "The cement *may* be rejected if it fails to meet any of the requirements of these specifications."

Section 17.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "(a) Individual Sample.—If sampled in cars, one test sample shall be taken from each 50 bbl. or fraction thereof. If sampled in bins one sample shall [be taken from] *represent* each [100] *200* bbl. *unless otherwise specified by the purchaser.*
>
> "(b) Composite Sample.—If sampled in cars, one sample shall be taken from one sack in each 40 sacks (or 1 bbl. in each 10 bbl.) and combined to form one test sample. If sampled in bins or warehouses one test sample shall represent not more than [100] *200* bbl. *unless otherwise specified by the purchaser.*"

Section 34.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "The temperature of the room, the materials, the mixing water, the moist closet and [storage tanks] *storage-tank water* shall be maintained as nearly as practicable at 21° C. (70° F.) and *the mixing water; moist closet and the water in the storage tank* shall not vary from this temperature more than 3° C. (5° F.)."

Section 51.—Change the pressure to be used in forming briquets from 15 lb. to "between 15 and 20 lb."

Section 52.—Change to read as follows by the omission of the words and figures in brackets and the transposition of the sentences in italics:

> "The briquets shall be tested as soon as they are removed from the water. Tests may be made with any machine meeting the following requirements: [The machine shall have a capacity of 2000 lb.] *The machine shall be capable of weighing the applied load within 0.5 per cent of the nominal value. The sensibility reciprocal (the weight required to be added to the load to move the beam from a horizontal position of equilibrium to a position of equilibrium at the top of the trig loop) shall not exceed 1 lb. at the full capacity of the machine or at any lesser load.* The clips for holding the tension test specimens shall be in accordance with Fig. 7. The bearing surfaces of the clips and briquets shall be free from sand or dirt, and the roller bearings shall be well oiled and maintained so as to insure freedom of turning. The briquets shall be carefully centered in the clips and the load applied continuously at the rate of 600 lb. per minute."

The committee further recommended that the specifications be approved for reference to letter ballot for adoption as standard, to supersede immediately the present standard specifications, this recommendation requiring a nine-tenths vote. This recommendation was unanimously approved. On motion, the report of the committee was adopted.

A paper entitled "Portland Cement Research," by R. H. Bogue was presented by the author.

A paper by S. R. Mitchell entitled "Cooperative Checking of Cement Testing," was read by title.

The report of Committee C-11 on Gypsum in the absence of the chairman, was presented by J. W. Ginder. The proposed revisions of the Standard Specifications for Gypsum Partition Tile or Block (C 52 - 25) and for Gypsum Plasters (C 28 - 21) were accepted for publication as tentative as recommended by the committee. The committee recommended that with the approval of Committee E-8 on Nomenclature and Definitions the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 25 T) be adopted as standard. Mr. Chapman reported on behalf of Committee E-8 that this committee had reviewed the definitions and was prepared to approve the advancement to standard of a number of them. The definitions for the terms "aggregate," "consistency" and "plasticity" were under review by other sub-committees, either in Committee E-8 or Committee E-1 and should accordingly be continued as tentative. Approval of the definitions for the terms "gypsum plaster board" and "gypsum wall board" was withheld since agreement on these two definitions had not yet been secured between Committee C-11 and Committee E-8. Nine of the definitions had been reviewed by a subcommittee of Committee E-8 under the chairmanship of L. I. Neale, the representative of Committee C-11, and this committee had submitted as its report revised definitions of these terms. These were appended to the report of Committee E-8. Committee E-8 recommended the substitution of these revised definitions for those appearing in the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 25 T). It further recommended slight revisions in the definitions for "gypsum," "calcined gypsum," "gypsum plastering sand" and "sized gypsum." The recommendations of Committee E-8 had received the consideration of Committee C-11 and were found acceptable to that committee. The definitions for the several terms revised as recommended by Committee E-8 were approved for reference to letter ballot for adoption as standard. The remaining definitions were continued as tentative.

The proposed new Specifications for Gypsum Molding Plaster, for Gypsum Pottery Plaster and for Keene's Cement were accepted for publication as tentative as recommended by the committee. On motion, the report of the committee was adopted.

The report of Committee E-8 on Nomenclature and Definitions was presented by the chairman, Cloyd M. Chapman. In addition to presenting the activities of the committee during the year in reviewing the various definitions of the Society, the committee recommended revisions of the Tentative Definitions of Terms Relating to Specific Gravity (E 12 - 25 T), of the Term Sand (C 58 - 25 T) and of the Term Screen (Sieve) (E 13 - 25 T), which definitions were under the jurisdiction of Committee E-8. These revisions were modified in regard to the notes appearing under the Definition of the Term Sand and under the Definition of the Term Screen (Sieve). The recommendations of the committee were approved, the definitions being continued as tentative.

The proposed Definition of the Term Aggregate was accepted for publication as tentative as recommended by the committee.

The committee submitted as information the Definition of the Term Concrete, Definitions of Terms Relating to Cementitious Materials and Definitions of the Terms Moisture, Ash, Volatile Matter and Fixed Carbon. On motion, the report of the committee was adopted.

The report of Committee C-7 on Lime was presented by the chairman, H. C. Berry. The Tentative Specifications for Quicklime for Structural Purposes (C 5 - 24 T) were approved for reference to letter ballot as recommended by the committee. The proposed revisions of the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 - 25 T) were accepted, the methods being continued as tentative. On motion, the report of the committee was adopted.

The meeting then adjourned till 8 P. M.

THIRTEENTH SESSION—FRIDAY, JUNE 25, 8 P. M.

On Concrete

President W. H. Fulweiler in the chair.

The report of Committee C-9 on Concrete and Concrete Aggregates was presented by the chairman, Cloyd M. Chapman. The proposed revisions of the Tentative Specifications for Concrete Aggregates (C 33 - 23 T) were accepted as recommended by the committee, the specifications being continued as tentative. On motion, the report of the committee was adopted.

The following papers were then presented and discussed:

"Concrete Specification Problems," by Cloyd M. Chapman—presented by the author;

"Concrete in Tension," by A. N. Johnson—presented by D. A. Abrams;

"A Simple Device to Obviate Capping of Concrete Specimens," by W. F. Purrington and James McCormick—presented by Mr. Purrington;

"Effect of Calcium Chloride on Transverse Strength of Concrete Aged at Various Temperatures," by L. C. Stewart—presented by the author;

"The Autogenous Healing of Concrete and Mortars," by H. J. Gilkey—presented by F. E. Richart.

The winners of the Golf and Tennis Tournaments were then announced and the prizes awarded by E. D. Boyer on behalf of the Entertainment Committee. The A.S.T.M. championship golf cup and medal for the low score were won by E. W. McMullen of Kenosha, Wis. The A.S.T.M. championship tennis cup and medal were won by R. J. Shoemaker of Chicago, Ill.

Other prize winners in golf and tennis were: J. J. Howard, C. H. Cox, C. W. Ten Broeck, R. E. Wilson, William McIntyre, W. M. Upson, D. W. Mulford, W. B. Price, H. W. Bates, H. S. Mattimore, A. F. Braid, G. E. Warren and R. D. Bonney.

There being no further business, the Chair declared the Twenty-ninth annual meeting adjourned *sine die*.

AMERICAN SOCIETY FOR TESTING MATERIALS

ORGANIZED IN 1898.
INCORPORATED IN 1902.

PROCEEDINGS

PART I

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

THE IMPORTANCE OF LITTLE THINGS IN THE STANDARDIZATION OF METHODS OF TESTING

ANNUAL ADDRESS BY THE PRESIDENT, W. H. FULWEILER, JUNE 22, 1926

During the last twenty-five years our past presidents have covered nearly every phase of the work of our Society in their annual addresses, from the Utility and Justification of Engineering Societies to the Relation Between Research and the Activities of our Society. One feature, however, of our work does not seem to have received attention and as it is one in which I am particularly interested, I have chosen for my subject "The Importance of Little Things in the Standardization of Methods of Testing."

In the objects of our Society as set forth in its charter, we have recognized the equal importance of the standardization of specifications and methods of testing and the promotion of knowledge of engineering materials. If you will consider the matter more closely, however, it would appear that the standardization of methods of testing perhaps should come first. Specifications are but a concrete expression of our knowledge of materials so that we cannot have specifications until we have a working knowledge of the materials under discussion. This knowledge must be quantitative if we hope to use it in specifications and the only way we can secure this quantitative knowledge is through the application of standard methods of testing.

Specifications may be divided into two classes: (1) primary specifications which specify properties that directly determine the suitability of the material or product for its intended use, and (2) secondary specifications, the requirements of which are indirect and do not in themselves necessarily determine the actual suitability of the material or product.

The greater our knowledge of the materials and of their requirements, the more nearly can we write primary specifications, but there are many classes of materials of which our present knowledge of the essential requirements is not complete, and as a result, our methods of testing are empirical and they give rise to the use of the secondary type of specifications, or what are sometimes called descriptive specifications.

There is, therefore, a rather clear distinction between methods which determine fundamental characteristics of material such as its density, absolute viscosity of a liquid, tensile strength as in steel, or chemical composition, and those methods that give empirical results such as softening point, distillation, flash point, etc. The fundamental properties of a material may be determined in general by more than one method and the methods themselves may be refined to the highest degree of accuracy. On the other hand, there are a large number of methods, and this applies particularly to the non-metallic materials and to the bituminous materials generally, that do not determine fundamental characteristics of the material but rather empirical characteristics, the quantitative results depending entirely upon the method chosen and in many cases upon the skill of the operator.

It is particularly to this latter class of what may be called empirical or secondary methods that I will devote the most attention, for two reasons: first, that my experience has been largely with this type, and second, it is in the secondary methods that the description of the apparatus, its dimensions and the procedure to be followed in its use are so important, as the results may be greatly influenced by slight and at times apparently immaterial changes in detail.

In considering the standardization of a method of testing for use in a specification we should first be sure that the results will be of use in identifying properties that will be of service in securing a desired material or product. In the speaker's opinion in many of our specifications too little consideration has been given to this question and frequently we have requirements in the specification that will have no bearing whatsoever on the usefulness of the material but serve merely as a rough means of identifying the source of raw material. On the other hand, the method may be one of rather simple application and there are some laboratories that are loath to abandon a determination that has been shown to have little, if any, application to the material at hand, merely because it is a simple determination to make and it appears to make their analytical report more complete.

If we have agreed now that the method is worth standardizing, the speaker would like to emphasize the very great importance of thoroughly considering the fundamentals of the method. Upon what physical laws does it depend? Is it a method that can be expected to reproduce results, or is it one that is purely empirical, the reproducibility of the results depending entirely upon exact duplication of apparatus and conditions? Committee E-1 on Methods of Testing has been giving considerable attention to this phase of the question and has called the attention of the standing committees to its importance. As an example of the information that can be secured from a study of the basis of our methods, the method used for soluble bitumen may be cited.

The test consists in treating the sample with a solvent and determining either the amount of residue remaining on a filter or the amount of soluble material remaining after the evaporation of the solvent. A study of the principles underlying this type of method has indicated that the result may be influenced by the following factors: The purity of the particular solvent used; the amount of solvent used; absorption of solvent by the insoluble matter; the formation of colloidal suspensions of insoluble matter; the precipitation by the solvents of colloidal material; and various combinations of these effects. The effect of time, exposure to light and the characteristics of filtering medium are also of importance.

It must be evident that it is only by the very careful duplication of all the conditions that such methods can give satisfactory results and in any event, the results are purely proximate in their character.

In many cases, a careful study of the fundamentals underlying some of our methods will reveal similar conditions and in such cases we should recognize the fact and frankly state in the introduction to the method that the method is empirical and that the results may be influenced by a number of factors, calling particular attention to those factors which are most likely to have the greatest effect on the results.

I would call attention to the requests that have been made by Committee E-1 that there should be included in all of our methods a brief discussion on scope and applicability, so that we may prevent the use of a method by less well informed persons where it is obviously not applicable. This should in may cases prevent criticism of our methods when they have been improperly used.

When we come to a consideration of the description of apparatus used in the methods, there seem to be two schools of thought. One would describe in the utmost detail every piece of apparatus with its dimensions and tolerances, and the other would be content to describe suitable apparatus in more general terms without attempting to insist too rigidly on the use of certain specified materials, leaving a certain latitude to the judgment of the operator. From my own experience, I would strongly urge the use of the first method, even emphasizing the desirability of specific dimensions and the requirement of specific apparatus. This is due to the fact that whenever the method permits any choice it seems inevitable that the alternate apparatus used will not be suitable and the results will be affected.

If we permit a certain latitude in one portion of the method, it is but natural for the inexperienced operator to consider that he may as well use his judgment in other details, with generally unsatisfactory results.

It seems impossible that one can be too careful in proof-reading the text of a method. May I take for illustration the distillation method for road materials? This method was first published in 1911 as tentative and the cylinders to be used in receiving the distillate were given as graduated in 0.1 ml. As a matter of fact, this was in error; the cylinders were really graduated in 0.5 ml. The method was adopted as a standard in 1916 and was universally used throughout the United States in the distillation of tar road materials, yet it was not until 1925 that someone noticed that a 25-ml. cylinder graduated in 0.1 ml. was too long to be used in the apparatus as set up. It would be difficult to estimate how many people had read this method and used it daily and yet no one noticed the fact that the specified cylinder was obviously in error. Probably, the only method of eliminating such errors in detail is to have someone who knows nothing of the method set up the apparatus and then check it over for compliance with the specifications.

Another point that is frequently lost sight of is the giving of specific directions for actually assembling the apparatus. I will cite, for example, the method for the distillation of creosote oil. This had been used in the industry for many years prior to having been proposed as tentative in 1915. A cut is given of the assembled apparatus but nothing is said regarding the angle made by the delivery tube of the retort to the horizontal and yet it is well known that the results can be varied considerably by changing this angle.

In writing new standards, considerable study should be given to the dimensions and tolerances that are specified for the different pieces of apparatus to the end that we should be able to determine which are important and which are unimportant. I will illustrate this point by the float test, a method of testing the consistency of solid and semi-solid materials that was first presented to the Society through Committee D-7 on Timber as a part of the methods of analysis of creosote oil in 1917. Very few dimensions were given for the apparatus, but satisfactory results were obtained because the apparatus was all manufactured by one maker. Some years later, however, other makers began to manufacture this apparatus and it soon became evident that the dimensions originally given were not sufficient to insure satisfactory results, so the standardization of the test was taken up by Committee D-4 on Road and Paving Materials and after consultation with the U. S. Bureau of Standards, a very complete set of dimensions was adopted. It was soon found, however, that the committee had now gone to the other extreme and that the dimensions and tolerances that were adopted were such that many pieces of apparatus which had been retained as standards did not fulfill the present specifications and in general the average laboratory was not equipped to check its own apparatus due to the refinement in the dimensions used. The committee then undertook some cooperative work and actually determined by experiment with apparatus of different dimensions, what dimensions and what tolerances could be used without affecting the results beyond the experimental error and these revised dimensions are now in use.

In connection with the specifications covering dimensions and their tolerances, it may at times be necessary to use dimensions and tolerances to limits that require the use of micrometer microscopes and are beyond the ordinary laboratory, but it is believed that in general this should be avoided if possible. While we may specify that the instruments used in measurements of length, temperature, etc., shall have a certain accuracy when delivered by the makers, yet too frequently are we prone to accept this statement without further test and it seems essential that laboratories should have the means necessary to check the calibration of all such instruments. The fact should also be borne in mind that any working standard is liable to get out of calibration with use and that periodic checks are necessary. This may even apply to special pieces of apparatus that are reserved to be used as standard apparatus. Accidents may happen to these and the man who is the cause of the accident, to avoid censure, may say nothing about it.

Our committees should consider the discussion of methods for at least an approximate calibration of the "meters" used in their various tests. This type of calibration would not replace the calibration by national standardizing bodies such as the Bureau of Standards but should be of sufficient accuracy to indicate whether the apparatus is in need of such calibration. While these points should be merely laboratory routine, the lack of their observance is frequently the cause for costly disputes over the rejection of material.

In outlining the procedure or method of carrying on the determination, it is, of course, quite true that we cannot in general make our methods fool proof. We must assume that the operator has some knowledge of the work, yet there are many little details that have an important bearing on the results that can be covered in our methods and yet are sometimes omitted. It may require several years' experience with a method, however, before all of these important details become apparent.

In the determination of the softening point or float test on residues from creosote oil, it was found that the method of cooling the sample after it had been poured into the brass collar had an important effect on the results obtained. Some materials developed a crystallin structure on slow cooling that considerably increased the time required in the test, in some cases extending it beyond the specification limits, It was found, however, that by chilling the material immediately after pouring, this effect could be eliminated. May I again call your attention to the importance of little things?

When we come to express the results obtained by our standard testing methods, we approach a rather important problem. As I see it, there are three factors to be considered: the precision with which the results are expressed, the accuracy attainable by the method, and the reproducibility of results by different laboratories. These three factors in many cases, however, bear no relation to one another. When we see a result, say 20.31 expressed to two places of decimals, we would consider that it is expressed to a relatively high degree of precision; but this result may be a whole unit in error so far as accuracy is concerned, and it may well be that two different laboratories will not reproduce the same result to within ±2 units. It would seem that the precision with which we express results should bear some relation to our ability to duplicate the figures on consecutive tests, for there is evidently nothing gained by expressing, for instance, viscosity to fractions of a second when two consecutive runs may not check closer than five seconds.

The whole question of precision, accuracy, exactness and correctness could well be studied by Committee E-1 with reference to our methods.

Evidently only primary methods can be exact and by care we make the results free from error and by definition be correct, but the question of accuracy is not so clear when we consider the secondary methods. If we pass one definition of accuracy as "conformity secured by scrupulous care" as pertaining to correctness and consider the other definition as "something that can be verified and found correct," there is in general no method of verification except the method itself. Therefore, the method sets its own standard and it is quite conceivable that two laboratories may not agree as to what this standard is. The most important factor for consideration in such cases is the reproducibility of results that can be secured by the faithful duplication of conditions in the hands of skillful operators and this is the real standard to which we should work.

The determination of this reproducibility is a matter of cooperative work and the results of such work are the only real criteria of the soundness of the method. Experience indicates that it is quite easy for one laboratory to reproduce results to a fairly high degree of concordance and yet it may not check at all well with another laboratory that can reproduce its results to the same degree of concordance. When such a case arises, it usually indicates that there is some important detail in the description of the method or in the procedure that is lacking or that the two laboratories have placed different interpretations upon certain conditions.

The only satisfactory method of solving such problems is by cooperative work by a fairly large number of laboratories whose operators have had experience with the method in question. There is no form of committee activity that yields a greater return to the individual participants than such cooperative testing. If your work is close to the average, you are proud; and if it is off you have the opportunity to correct a condition that can be discovered at times in no other manner.

I believe that every standing committee should have a sub-committee or section on precision and tolerances and that its investigation of the methods of testing with references to these points will prove very valuable.

The findings of such a section in one committee were in several cases quite startling. For example, where it was the custom to take the average of the results on two samples it was shown that twenty-seven samples should be used to secure an accuracy of ±3 per cent. In another case, where a result was reported to one half a unit, it appeared questionable as to whether two units was not a better precision taking into consideration the ability of different laboratories to reproduce the results.

You will notice that in all of the foregoing, while I have attempted to stress the importance of little things in connection with our methods of testing, I have said nothing about sampling. I have intentionally omitted all reference to this subject, because the question of sampling is so important that it deserves far more time than is now available and we might profitably spend a whole evening in discussing this phase of our work which is so intimately connected with the method of testing and with the use of specifications.

It may appear that I have given too much attention to the difficulties that have been encountered in standardizing our methods of testing and have not pointed out that these instances of troubles are but a relatively few and have been encountered in over three hundred very successful methods of test.

This is quite true, but it is also true that we learn very little from success but a great deal from failure.

If I have been able to point out where some of the difficulties lie in the way of standardizing our methods of testing by stressing the importance of little things, to the end that in the future some of these difficulties may be avoided, my object will have been attained.

PROCEEDINGS OF THE FIFTH SESSION: EDGAR MARBURG LECTURE

June 24, 1926

The President (W. H. Fulweiler).—I am very happy indeed to have the opportunity of presiding at this session, in which we inaugurate the first of our Edgar Marburg Lectures. These lectures were instituted as the result of recommendations made by our Committee on the Correlation of Research, and their object is to bring to the Society men of especial distinction in various branches of engineering, to the end that we might hear of the latest developments in the knowledge of materials and of testing. In considering a name for this lecture, it was but natural that we should honor our first Secretary, Dr. Edgar Marburg, who held that office from 1902 until his death in 1918. From his first association with the Society and with its predecessor, the American Section of the International Association for Testing Materials, he took a prominent part in discussions and in the presentation of papers having to do with the purpose and intent of the newly organized body. Throughout his life, Doctor Marburg kept in close touch with the practice of his profession, with a conviction that to do so was essential to sound teaching. In view of this contact, he acquired a keen interest in the study of materials and he was one of the first to become active in the work of the Society for Testing Materials. His personality pervaded all its activities. It was at his suggestion that the present name of the Society was adopted, and the future policy as Doctor Marburg conceived it concurs with the accepted efforts of the Society. He was so close to every significant development of the Society that it is difficult to chronicle even a few of his more notable achievements. He had at all times the interest of the Society at heart and no one could have been more jealous of its good name. He would make any sacrifice and go to any length in working to advance its interest.

The selection of the lecturer is left to a committee of three and they have this year chosen, for the first Edgar Marburg Lecture, Professor Arthur Newell Talbot, who needs no introduction to any A.S.T.M. audience. Professor Talbot is a past-president and an honorary member of our Society. He is a past-president and honorary member of the American Society of Civil Engineers. Professor

Talbot's life work has been devoted to teaching the science of engineering. Since 1885 he has been connected with the University of Illinois and is at present Professor-in-Charge of Theoretical and Applied Mechanics. He has been in research for many years and has carried on a large number of researches on many subjects having to do with concrete and reinforced concrete. He is in charge of the work on track stresses of the American Society of Civil Engineers. Professor Talbot has been honored by the University of Pennsylvania, by the University of Michigan and by the Western Society of Engineers. It is therefore with a great deal of pleasure that I present to this audience Professor Talbot for the first Marburg Lecture.

> [Professor Talbot then delivered the first Edgar Marburg Lecture, entitled "Research and Reinforced Concrete as an Engineering Material." The lecture appears on page 50.—ED.]

THE PRESIDENT.—Professor Talbot, I know I am voicing the feeling of all of our members when, in the name of the Society, I thank you for the very fitting tribute you have paid to the name of Doctor Marburg, for the very interesting historical review you have given us of the early research work in reinforced concrete, and the very competent discussion you have made of the various engineering factors which have been covered in such research.

I am very happy to be able to announce that Mrs. Marburg is present this afternoon and asks the opportunity of expressing her appreciation of the manner in which we have honored the name of Doctor Marburg. To many of our older members she will not be a stranger, but to some of our younger members she will be a stranger and I therefore wish to introduce Mrs. Marburg.

MRS. EDGAR MARBURG.—In thinking over this tribute, I have been so much touched by the outward and visible sign and the inward and spiritual grace of it, that, as your President has said, I have asked for the privilege of thanking you in person. Your associating Edgar Marburg's name with these lectures on outstanding engineering achievements presented by distinguished members of that profession, is a signal honor of which he would have been most appreciative, and which makes me very proud. This is a fine recognition of his services for you, but for him, the discharge of those services was a glorious opportunity and its own reward. As your President said, he labored unsparingly, but joyously, too, and as the Society developed and grew, so did he. I remember, as if it were yesterday, his animated expression, and earnest tones, when he told me of his election to be your Secretary-Treasurer. He and I were young when the American Society for Testing Materials was born, but those initials were afterwards familiar household words; in fact, so intense was the interest of my partner, that the Society became my very best friend-in-law. Now I should like to ask for all of the privileges of that in-law-ship, and of my years, and extreme indulgence beside, while I hint at my deepest and most intimate reactions to this memorial. All of us know that there is a longing in every human heart when the great transition comes, to be remembered by those who are left, and among the loftiest, purest emotions of which we are capable, are those that prompt us to fulfill that longing. This you have done, and I, to whom Edgar Marburg will always be just in the next room, can find no adequate words to tell you of my appreciation of your wish to keep with you the something of himself, that Edgar Marburg bequeathed to this Society. [The members rose and heartily applauded the speaker.]

RESEARCH AND REINFORCED CONCRETE AS AN ENGINEERING MATERIAL

EDGAR MARBURG LECTURE, BY ARTHUR N. TALBOT,

JUNE 24, 1926

The establishment of the Lecture must be regarded as a milestone in the history of the Society. To name it the Edgar Marburg Lecture is to recognize the work and worth of one who contributed greatly to the life and character of the Society. Edgar Marburg was a teacher of renown, an engineer of understanding and wisdom, and a seeker after truth in the engineering world, but to us he was a builder of the American Society for Testing Materials. For sixteen years he was the chief agent in guiding the Society into a great technical organization and a power in the engineering and manufacturing world. The accomplishments for scientific progress, for improvements in contractual relations, for standing in public estimation made in that time were noteworthy. It is due to Edgar Marburg to say that much of the wonderful vigor and remarkable accomplishments and unstained record of the American Society for Testing Materials was due to the energy, vision, and character of this man, and it is fitting that the Lecture now established should bear the name of one whose work was so intimately ingrained into the life of the Society for so many years.

It is indeed a high honor to be selected to give the Edgar Marburg Lecture. I assure you that the honor is appreciated, though none will recognize more fully than myself the scantiness with which I can measure up to the standards it should carry.

The statement of the establishment of the Edgar Marburg Lecture prescribes a description of outstanding developments in the promotion of knowledge of engineering materials. In casting about for a suitable topic I came to the conclusion that my own connection with the promotion of knowledge of reinforced concrete since the date of incorporation of the Society in 1902 has seemed sufficiently close to warrant making the address a discussion of the relation between research and the progress and development of reinforced concrete in the United States as used in building and structural work, especially for the period since 1900. As the developments in reinforced concrete involve technical matters of considerable complexity it will not be feasible or fitting in the address to give technical details or even the principles learned; instead, reference will be made to the nature and purpose of some of the developments.

To some it may not seem fitting that reinforced concrete is called an engineering material. The combination of concrete and steel, frequently called concrete-steel in the earlier days, has many essential individual properties and characteristics that are of importance in the design and construction of structures, properties that are separate and distinct and different from the properties of concrete and of steel, and that markedly influence the usefulness of the combination and greatly affect the allowable working stresses and the division and distribution of bending moments in the structure and the allowable and desirable forms of construction to such an extent that concrete-steel has been considered an engineering material of distinct and individual characteristics. Necessarily the properties of the concrete and the steel both contribute to the properties of the combination. Adequate technical knowledge of reinforced concrete evidently is essential to an intelligent, safe, and economical engineering use of this material, and a dissemination of this technical knowledge among engineers must have preceded any general and extensive utilization of the material.

At this point it may be well to turn a moment to refer to the great changes that have taken place in the nature and the bases of the practice of engineering and to the extent that engineering is now dependent upon technical knowledge. The pioneers in American engineering depended almost wholly on ingenuity, experience, precedent, vision and judgment, and engineering science played a minor rôle. The increasing magnitude and difficulties of engineering projects, the need for greater permanency, economy, and safety and the varying and diversified nature of engineering work have greatly emphasized the importance of basing engineering art more fully on engineering science. It will, of course, not be overlooked by any one that engineering must continue to need ingenuity, experience and judgment, and rules, precedent and vision, but more and more, as time has gone on, has it become dependent on science and that accumulation of applied science that may be grouped under the term "engineering science." And it is plain that engineering science must be nurtured, fed, and developed through research.

And it is a striking fact that at the beginning of the twentieth century in the United States the technical knowledge of reinforced concrete was very meager (with the exception that in some degree the art of constructing reinforced concrete arches was fairly well advanced), and the diffusion of any technical knowledge of the material was quite limited. In fact, up to a quarter century ago reinforced concrete had been of little interest to the engineer and architect of the United States; the principal use of concrete had been in foundations and in the interior of massive parts. A few like Ransome in California had done pioneer work with reinforced concrete and other Americans had made use of it in small ways, but haltingly. Reinforced concrete had made a start in Europe at an earlier date and a number of engineers there had learned considerable in the technique of this form of construction. An occasional use of reinforcing iron to give stability to forms of masonry construction had been noted in an even earlier time. The Frenchman Coignet in a book published in 1861 described the advantages of the use of iron in masonry or in concrete; in 1869 he was granted a patent which relates mainly to artificial stone monolithic work. Monier's publication in 1873 and his patent obtained later, the tests of Hyatt (an American), Hennebique's patent and his many examples of construction work, the writings of Wayss and the tests and analyses of others all contributed to the considerable development of reinforced concrete in Europe, so that before the end of the nineteenth century with the experience gained in its use in a variety of ways the form of construction had gained a foothold and a considerable fund of technical knowledge had accumulated. Strangely, this source of knowledge was not utilized to any extent by American engineers, and many practitioners were woefully ignorant of the principles that should govern in reinforced concrete design. Altogether there was an unusual opportunity for constructive research in the field.

In judging of the part that engineering research has played in the expansion and development in reinforced concrete, it will be well first to consider the state of the art, the diffusion of knowledge, and the general attitude toward concrete and reinforced concrete that existed in the United States less than twenty-five years ago. Looking back, it is not out of place to say that among engineers, architects, and contractors in this country there was a general lack of technical knowledge of the principles of reinforced concrete construction, as well as a dearth of experience in the practical side of the construction, and that there were many mistaken notions prevalent. In the earlier days I have known of most absurd attempts at reinforcing and ludicrous errors in design. The purpose, the need, the efficacy of certain forms and methods of reinforcing were frequently misunderstood. I recall a handbook of reinforced concrete, brought out by a well-established publisher of engineering books, that contained statements concerning the way in which certain reinforcing bars took stress and resisted certain action in a beam which were so erroneous as to seem very funny; methods of calculation of strength were applied to the design of beams of enormous dimensions, and elaborate tables for office use given, all based on erroneous and absurd ideas of the properties of reinforced concrete. I hope I shall not be taken to mean that there were not those who were skilled and skillful in design and construction even in the early period of development here.

Besides all this, in its earlier stages a new art must prove itself sound, must do things to gain the confidence of constructor and owner, and insurer and banker. It must demonstrate its correctness with certainty, its utility with satisfaction, and its safety and economy with conviction. And a new art does not burst full-blown into action; it must grow and develop and be trained toward perfection. I trust that before I am through it will be apparent to all that engineering research in the technical side of reinforced concrete has had a most important part in the development and extension of reinforced concrete construction in this formative period, and that that research is entitled to be thought worthy of comparison with research on other kinds of engineering materials.

Doubtless in this company there would be substantial agreement on what constitutes research, how it should be conducted, and what its object should be; and yet it may be well to digress somewhat and to give some consideration to the matter in order to bring out the features of investigation which have influenced the development of practice in reinforced concrete in this country. Perhaps something may be gained at the beginning by an illustration. Some years ago, having to be present through the hour at a written quiz of 120 students with whom individually I was but slightly acquainted, I interested myself in studying their faces and characteristics. I observed that two were red-headed and that three wrote with the left hand. My assistant checked the data of my observations and declared them correct. Here then were two of the requisites generally given for the conduct of research—observation and verification. But what was the value of the data as technical knowledge? Were the observations representative? Did they mean any thing? Was the information something on which to base conclusions and establish principles or was it an accidental and superficial peculiarity, whether from heredity or environment? The number of red heads seemed relatively small, especially when compared with the number of bright heads among the co-eds on the campus at that time. The number of left-handed men appeared small too, but their scarcity may have been due to modern methods of teaching penmanship whereby even the left-handed individual is encouraged to learn to use his right hand for pen and pencil. There was no opportunity to relate these peculiarities to the characteristics of the individual, to his method of thinking and acting, or to his possible fitness for engineering training. Even if observations taken with classes over a series of years corroborated the findings on the class of this particular year, the results could be characterized only as data of curious phenomena, their relation to other things uncertain, of little value as statistics. It is clear that what we call research in engineering materials should possess characteristics other than found in this incident.

To begin with, it may be stated that the purpose and aim of engineering research is to establish principles and bring out fundamental technical knowledge of the behavior and action of the material under known conditions; primarily, basic principles, and secondarily subsidiary and auxiliary principles. In experimental work there should result authoritative data upon which to base discussion and draw conclusions. In the analytical and mathematical work an essential part of the procedure is to base the analytical work on definite assumed conditions and to connect it up with known facts in such a way as finally to establish the validity of the conclusions, or it may even involve breaking ground to show the need of experimental work in certain directions, experiments that may serve to establish principles until then undetermined.

And while on a digression your further indulgence is asked while some rather commonplace remarks are made on the conduct of research of the kind here referred to. Many years ago, when just out of college, I was employed on the location of railroad lines over mountain passes in what was then called the Far West. In such little known territory the procedure in sequence included exploratory work, reconnaisance, preliminary and final location, construction, and operation. In the first stages there were considerations of possibility, practicability, revenue, net returns, ways and means—all of these were fairly definite problems considered by well-established railroad methods. But in research the exploratory stage at the start includes a study of the nature of the problem. What is known? What available technical knowledge has a bearing on it? Is the problem likely to be susceptible of solution, or at least may results of some value be obtained? Is the undertaking worth while? And then in the reconnaisance stage—trying out methods, doing a little this way and that, finding difficulties, learning what snags may be in the way, and getting experience through trials and preliminary results—then may come the developing and perfecting of the procedure and the methods of attack, the separation of variables, the repetition for confirmation, the further steps for exclusion of variables, and even more intensive investigations in particular lines. Throughout, as well as at the end, there should be consultation and discussion with others familiar with the field, to avoid the possibility of going astray. It will be seen that I am referring not to amateurish, dabbling, or spasmodic work, but to real intensive research. And reinforced concrete is an example of the simpler problems and the greater ease attending the earlier stages of research. As knowledge develops, the problems become increasingly complex and the research requirements more difficult.

Perhaps I can best bring to your attention the type of principles that has been established largely through the research on the properties of concrete and reinforced concrete since the opening of the twentieth century by a reference to the type of questions that confronted the Joint Committee on Concrete and Reinforced Concrete when it was organized in 1904—questions on which there was then but little authentic experimental information applicable to the methods of construction in vogue in the United States. In beams, attention had to be given to the permissible working stresses in reinforcing bars for different kinds of structures and different forms and qualities of bars, and to whether the tensile strength of the concrete may be utilized for the resisting moment of the beam. What working stress in compression may be allowed in the concrete, or better, what percentage of reinforcement for the given working stress in tension is permissible? How may requirements for the quality of concrete be set forth? How does this material resist web stresses, and knowing this how shall the web stresses be calculated, and what allowance shall be made for the various forms of web reinforcement,—a most difficult and vexing question,— particularly before measurements of the strains developed in the web reinforcement had been made. How does a bar develop bond resistance and how much resistance is available and in what way does it depend upon form and size? What are the conditions of stiffness and elasticity in this material and how do these conditions affect a member or frame? How do columns act under load and what is their strength when reinforced in various ways? What is the effect of spiral reinforcement, both on the ultimate strength and on the useful strength of the column, and what of the combination of longitudinal and spiral reinforcement? Must columns resist bending put into them by the floor system and in what way and to what extent will the several kinds of columns develop such resistances? How do footings act and how may they be designed? Has the flat slab a mysterious and wonderful strength that baffles analysis? What information should be made available to determine what specification may best be made for concrete itself—especially with present-day methods of transport, placing and tamping? All these and many others the Committee found needed answering. Many of them would be thought questions of engineering mechanics and engineering practice, but all needed tests, real experimental facts on which to base engineering analysis and engineering judgment, even though it is true there were engineers, as strangely there are still, who persisted in basing their views solely on their own analytical inner consciousness. Many of the questions considered now seem trifling, others trite, still others are yet far from being fully settled.

It is well to recognize that the Joint Committee on Concrete and Reinforced Concrete greatly aided and stimulated research in this field. The Committee was formed by joint action of the American Society of Civil Engineers, the American Society for Testing Materials, the American Railway Engineering Association, and the Association of Portland Cement Manufacturers, and a few years later representation was given also to the American Concrete Institute. A report of the Sub-Committee on Plan and Scope made in 1904 recognized clearly that it was vitally necessary to have extensive and adequate tests made to determine the properties of concrete and reinforced concrete on which to base conclusions and recommendations for design and construction and for regulating practice in this promising type of construction. A Committee on Tests was formed, whose most active members were Messrs. Hatt, Humphrey, Thompson, Turneaure, and the speaker. For several years this Committee outlined and suggested and stimulated research. Through their exertions the hearty cooperation of college laboratories and other laboratories throughout the country was obtained. The Structural Materials Laboratory of the U. S. Geological Survey at St. Louis, the laboratories of the University of Illinois, University of Wisconsin, Purdue University, Ohio State University, Massachusetts Institute of Technology, and various others made valuable contributions to knowledge, and later still other laboratories added contributions in many ways.

The information so obtained, together with that derived from other sources including foreign research, helped to enable the Joint Committee on Concrete and Reinforced Concrete understandingly and intelligently to make the progress reports of 1909 and 1912 and the final report of 1916—documents that, while they were attacked as being both radically unsafe and unsound, and unduly and inordinately conservative, time has shown on the whole to be sound and constructive and to have exercised most important and beneficial influence on engineering practice in this country through many years. It should be understood, of course, that this committee was only one of a number of influences that stimulated engineering research through this period.

I wish there were opportunity to relate in a historical way something of the researches that contributed greatly to the progress of the new art. At the risk of seeming to overlook many important contributions it may be of interest briefly to refer to some of the problems taken up and some of the research projects worked upon.

In this country before 1904 a little experimental work had been undertaken which had been helpful in various ways, but perhaps most largely as a reconnaissance into the method of testing reinforced concrete beams. The tests of large beams made in January, 1904, at Rose Polytechnic Institute by Howe, ably assisted by Condron, and those made at the University of Illinois in the spring of 1904 gave what was probably the first reliable experimental evidence brought out in the United States on the position of the neutral axis in reinforced concrete beams, and with the careful and complete measurement of strains in concrete and steel and the full description of the action of the beams under load given in the published reports of the tests, confidence in the methods of testing and the applicability of the results to practical work was established. The tests at the University of Wisconsin in 1904 gave clear evidence that the tensile strength of the concrete gives way at low loads and that this tension can not be relied on to resist the longitudinal stresses set up in flexure. Of other tests in great variety made in various laboratories in the years immediately following, reference may be made to tests for determining limiting compressive stresses, methods of web reinforcement, action of tee beams, and comparison of reinforcement with plain and deformed bars. The Structural Materials Laboratory of the U. S. Geological Survey at St. Louis under the direction of Humphrey early produced a large amount of valuable and timely data. The tests at the University of Wisconsin under Withey were valuable contributions. The Engineering Experiment Station of the University of Illinois, established in December, 1903, began at once a comprehensive program of tests on beams, slabs, columns, and building structures and on the properties of concrete, which has been continued as means permitted up to the present day.

But research is always found to have incidental by-products not on the original program, and there are other needs than those for technical knowledge. Did not the tests of 33-ton slab beams made for the Illinois Central Railroad in Chicago in 1908 and viewed by a hundred engineers give to these engineers and others an appreciation and a confidence in this new form of construction otherwise not easily gained? And did not the sight of the comparative tests of large cast-iron culvert pipe and reinforced concrete pipe give these same engineers a new idea of the applicability of this material? Similarly, the early tests on reinforced concrete buildings—the strains in the concrete and the steel being measured first by Lord, followed by Hatt and Slater and Gonnerman and Richart and others—not only gave needed information on the action of the structural members of the building, but conveyed to designer and constructor and owner a confidence in reinforced concrete that was lasting, even though, as many will remember, it was difficult to overcome the prejudice against those fine cracks that the whitewashed surfaces exposed to the view of the layman, cracks which the research man knew from the beginning must accompany the loading of such structures.

Reference may well be made to research in reinforced concrete along other lines. The work of Abrams on bond between concrete and steel will long remain a classic. The tests on wall footings and pier footings, also made at the University of Illinois, have given the whole profession information and fundamental conception of the action and resistance of footings that seem to have proved very useful. The investigation of columns at the University of Wisconsin, University of Illinois, and Lehigh University, and that important series of the American Concrete Institute made by its committee at the Pittsburgh Laboratory of the U. S. Bureau of Standards and the tests of McMillan on shrinkage changes added needed knowledge of this important member. I wish I could talk in detail of the column tests. The tests of reinforced concrete frames by Abe at the University of Illinois and the later extensive tests by the Emergency Fleet Corporation threw much light on properties of reinforced concrete when applied to forms of construction that will be used more and more in the future. For the high character of the work in various lines carried out by the Emergency Fleet Corporation credit is due Slater, Lord, Richart, and other investigators.

In the important field of flat slab construction, the many tests of buildings made in various places and the tests on experimental slabs at Purdue University and elsewhere, as well as the unpublished tests of cantilever slabs at the University of Illinois, have given noteworthy information, and these and the more recent analytical investigations of Slater and Westergaard have changed the status of the flat slab from a mystery or a miracle to a substantial reality.

As bearing on the nature of the research to be undertaken it may be noted that the purpose and use to which a material is to be put, determine the sort of properties and qualities desired in the material and indicate the nature of the information wanted on its behavior and action when subjected to the kind of influences it may be expected to resist. The range and diversity of the properties desired and of the influences to be resisted are indeed very great, as would be recognized at once if an enumeration of purposes, uses, influences, and attending conditions were to be made. A structural material must resist the various stresses and strains that are produced by the action of loads and physical forces applied to the structure and its various members. The loads considered in the design are nominal or working loads which it is assumed the structure is intended to carry. Altogether too often the engineer considers that these loads are the real loads and the only loads that will come on the structure; he may then blindly and unintelligently apply the accepted working stresses to the design of the structure, and to a certain extent—quite frequently to a large extent—he is thus working by rule-of-thumb. He thinks he is protected by some factor of safety, unknown in amount. He does not know (nor even does he give thought to it) to what extent the values chosen for these standardized working stresses should be dependent upon the properties of the material beyond the assumed stresses and upon its behavior and its resisting action for stresses in the material that are well above these nominal stresses and that may be developed in the structural member for conditions and modes of action not contemplated in the calculations but which may some day exist in the structure. Uneven settlements and unusual shrinkage, with unconsidered distribution of loads and undetermined action of parts, or other variations from the assumptions made, may result in a strong draft on the reserve properties of the material. Although it is the common habit to rely on the so-called factor of safety as full provision for unconsidered conditions, or in other words to consider that the values of the working stresses have been established with all unusual conditions in mind, it is plainly the duty of the responsible and intelligent engineer to become adequately informed on the properties of the material throughout the whole range of its useful resistance and to know the effect of such properties upon the resistance of a member throughout this range and their influence upon the stresses and the behavior in other members in the structure at the same time. I wish here to state my belief that the importance of knowing the properties of a structural material throughout the whole range of its resistance up to a critical ultimate is not appreciated by engineers to the extent that is warranted by its usefulness in deciding many questions of great practical importance.

Knowledge of the properties of the structural material considered in this address, reinforced concrete, is then essential to intelligent design and construction as well as to a proper consideration of allowable working stresses and proper requirements in design and construction. Since it is a compound material, its mode of action throughout a wide range and under a variety of conditions naturally varying from that of either of the constituent parts, the properties of the combinations, as well as those of the constituent parts, need determination.

And the concrete itself within the range of its useful resistance is not altogether an isotropic, elastic material; its properties over a considerable range should be learned. It should be found in what way and to what extent the useful properties of the combination of steel and concrete will differ from those of the constituent materials and wherein the range of useful properties extend above and beyond those found in plain concrete. Knowledge of this nature can be obtained only through research.

The action of the reinforced concrete beam is of interest as illustrating properties of the material. Plain concrete beams fail suddenly in tension and at relatively low resisting stresses in the remote fibers and correspondingly small strains. When the beam is reinforced on the tension side the concrete and the steel at first share in the tensile resistance, but when a stretch is developed approximately equal to that producing failure in plain concrete the tensile resistance is overcome at one or more points, and with the springing back of the concrete on the release of part of the tension in the concrete, cracks will form, though these may not be visible at first on the surface of the beam. Due to the irregularity of size in the particles composing the concrete the cracks may not at first be continuous across the beam section, and so the discontinuity of the material may occur at different places along the beam, the relief in strain in the concrete being distributed in such a way that the tensile stress still exerted in the concrete contributes to the stiffness of the beam throughout a considerable part of the range of loading. At first the presence and distribution of this remaining stress in the concrete may appear to give assistance to the beam action and the stresses in the steel measured over a few inches of gage length are insufficient to account for the full bending moment, though, of course, the stress at a crack must be considerably greater than that derived from the measurement by averaging over the gage length. This insufficiency of stress averaged from the full gage length led many to believe that there was strength efficacy in the concrete at stresses in the reinforcement well above the usual working stresses. At higher loads, however, the cracks in the concrete become continuous and reach the region of the neutral axis, and the measured strains in the reinforcement are sufficient to account for the full value of the applied bending moment. As this condition exists at the stage of loading which is available and useful as reserve strength in the structural member, and as working stresses must be based upon or bear a proper relation to the conditions which give this reserve strength, it is obvious that tensile strength in the concrete may not properly be considered as contributing to the longitudinal fiber resistance of the ordinary beam analysis.

On the compression side of the beam the conditions follow fairly well the usual assumptions up to a strain at the remote fiber equal to that at which concrete may be expected to fail in simple compression, say at a strain of 0.0012 or 0.0015 in. per inch. With further application of load, instead of breaking as the concrete would in simple compression, the strains or deformations continue to increase and the maximum load is not reached until the strain at the remote fibers becomes about double that found in simple compression failure. Available evidence seems to indicate that the concrete which is thus compressed beyond its ordinary point of failure retains the strength developed at its ordinary ultimate or may exert a slightly higher strength through this range of greater strain. The fibers below the remote ones do develop higher compressive strains than before and thus the total compressive stresses developed in the beam may be in excess of the amount which would be calculated on the basis of the compressive strength under ordinary assumptions. In deciding upon increases in allowable working stresses in beams, this phenomena seems to have been treated as meaning that the strength so found is available as reserve strength, although there is little information on its usefulness under repeated application of the higher loads referred to.

The nature of the bond resistance between the concrete and the reinforcing steel, the slip between the two under different conditions of stress, the effect of cracks that have formed in the concrete, the results attending long continued loading and repetitive loading, the effectiveness of the deformed bar, the efficacy of bends and hooks,—all these and many more have had much experimental study which has given knowledge having an important bearing on an essential property of reinforced concrete.

Much experimental study has also been given to the web stresses in beams and to the resistance to diagonal tensile forces furnished by various forms of web reinforcement, although it may be agreed that this subject deserves further investigation and a bringing together of the available knowledge in order to unify opinions and clarify ideas among constructors.

The subject of compression members has deservedly been given attention as a research topic. Concrete is relatively strong in simple compression and is thus useful for taking direct loads under proper conditions. In frames and with restrained connections the bending moments developable make plain concrete columns unacceptable. Reinforcement with longitudinal bars adds desirable properties and under suitable conditions makes satisfactory compression members, but continued shrinkage and plastic flow under load bring in difficulties, and the common practice of splicing or lapping reinforcing bars introduces conditions that are incongruous and this combination needs fuller experimentation. Research on concrete compression members with lateral reinforcement in the form of spirals, with or without longitudinal reinforcement, brought out the fact that such a combination may develop far higher compressive strength than the plain concrete can offer and gives greater deformations before failure, thus providing an element of toughness that is of value. With the decreased stiffness through the range of increase in strength, however, the value of the new strength as available resistance to bending moment is relatively smaller and the reduction in stiffness of the material through the new range of strain makes the element of length of column a most important one and limits the effective usefulness of the spiral in the longer lengths of columns. The whole subject of reinforced concrete columns is worthy of further research and even of fuller interpretation and dissemination of the experimental work already carried out. Engineers are prone to derive long and complicated analyses of column action basing them on insufficient and even erroneous assumptions and misinterpreted data and on isotropic and elastic conditions of the concrete, thus adding to the confused notions and the misunderstandings already existing. This condition is exemplified in papers on the subject published in recent years. It may then be emphasized that the reinforced concrete column is still a worthy research subject.

At this point I should like to make reference to a recent research on the resistance of concrete to compression which it seems to me is of such value in its bearing on reinforced concrete columns as to warrant mention. The work was ably carried out during the past year by Mr. Anton Brandtzaeg, a graduate student at the University of Illinois. The tests were made by applying compression loads in one, two, and three directions. The first result to which your attention is directed refers to the action of spirally reinforced specimens. As is well known, when the shortening of the spiraled specimen approaches that strain at which plain concrete may be expected to fail, the spiraled concrete exhibits new and quite different properties. Reinforcement of differing character was used, from soft steel to steel having an ultimate strength of 170,000 lb. per sq. in., and the percentages of reinforcement varied from 0.5 to 4.4 per cent. The additional load carried by the spirally reinforced specimen as compared with a plain concrete specimen may be termed the additional load due to spiral, and the corresponding additional axial or longitudinal resisting stresses may be called the additional longitudinal stresses developed through the presence of the spiral. An important principle established by these tests is that the ratio of the additional longitudinal stress applied to the specimen to the lateral stress applied by means of the stress developed in the spiral reinforcement has a constant value irrespective of the percentage of the reinforcement (within the limits of reinforcement used) and irrespective of the nature of the steel and whether it has passed its yield point. The one limitation found is that when a soft steel has so far passed its yield point that its rate of stretching as compared with increase in stress (instantaneous modulus) is greater than some limiting rate of deformation in the specimen, the load carried by the specimen reaches a maximum and a further increase of stress in the spiral results in no increase in carrying capacity. The constant value of the ratio for the variety of specimens tested is 4.1; that is, the additional longitudinal stress furnished by means of the spiral is 4.1 times the lateral pressure on the specimen given by the spiral. This ratio applies not only to the maximum load, but also to a considerable range of loads below the maximum. The highest loads carried were by specimens spiraled with 2 per cent of the hard steel, the measured strains in the spiral indicating a stress of 140,000 lb. per sq. in., when the steel broke through gage holes that had been drilled in it. The loads on these specimens averaged about 8000 lb. per sq. in., the strength of the concrete itself tested in the ordinary way averaging about 2100 lb. per sq. in. The restraining stress on the concrete, due to the stress developed in the spiral, corresponds to a lateral pressure of about 1400 lb. per sq. in. Bearing on the action of spiraled columns were tests made on concrete specimens subjected to lateral liquid pressures of varying intensities at the same time that loads were applied longitudinally, the tests being made with three richnesses of concrete. The results correspond closely to those of the spiraled columns. It is worth mentioning that one set of specimens having a plain concrete strength of 2500 lb. per sq. in. carried maximum loads as great as 18,000 lb. per sq. in. when a lateral pressure of 4000 lb. per sq. in. was applied. These three-dimensional tests were undertaken in a search for causes of failure of materials and to learn whether accepted conclusions from the relation of principal stresses are sound.

The second result of Mr. Brandtzaeg's research related to the method of failure of concrete when a compressive force is applied. He concludes—and the tests bear this out—that the common conception that failure of concrete loaded in compression is by shear at angles with the longitudinal axis is incorrect; the shearing phenomena noted develop some time after the maximum load is reached and after changes have gone on in the concrete which greatly modify its resistances. At loads of 80 per cent, or so, of the maximum the relation of lateral strain to longitudinal strain abruptly changes, the so-called Poisson's ratio increases rapidly, reaching a value of 0.50 or more, and the volume of the specimen instead of decreasing with added shortening, expands, becoming at the maximum load as great as before it received load, or even greater. Further shortening brings more changes until the specimen finally collapses. Mr. Brandtzaeg has developed a theory of failure, which appears to have a scientific basis and to have application to other materials than concrete. Among other things it includes the idea of a punching action of particles against and between other particles and in a variety of directions. It is thought too that such a theory of failure may throw light on the resistance of spiraled columns. Altogether, Mr. Brandtzaeg's research is most interesting and valuable.

Mention need only be made of floors and frames and footings to bring to mind a variety of forms of construction, for the design of which a knowledge of the properties of the reinforced concrete has been essential. Without the results of the experimental research on such members and structures that have been carried out in the past twenty years, the designing engineer would be working in the dark or would be unduly cocksure or greatly over-anxious.

I wish there were opportunity to relate the progress made in our knowledge of the constituent material, concrete itself. The early studies of such experimenters as Rafter, followed by the important researches of Fuller and Thompson had furnished information of great value. When the seeming exigencies of easy transportation of the concrete and its quick and cheap placing in the structure brought into general use the over-watered mixtures, in utter disregard or ignorance of the serious reduction in the strength of the resulting concrete and frequently also of the effect on the durability of the structure, it was the results of research on an extensive scale systematically disseminated that convinced engineers, even against their will, that over-watered concrete has defects and drawbacks and that the judicious control of the mixing water is a most important element in securing satisfactory construction. While many contributed to this conviction, great credit is due to D. A. Abrams for both the experimental data and the advocacy of reform. In recent years, too, attention has been given to the relation between the grading of both fine and coarse aggregates and their proportioning with respect to each other and to the cement, and various efforts to devise methods of proportioning having a scientific basis have been made. Notwithstanding the generally good results that have been attained, it is my opinion that the proportioning of concrete is worthy of further study and research and that the future will bring far better methods of design and control and requirements for construction which will be accepted in practice as essential to insurance of excellence of quality. And I would include in any program of research also a study of the elements which tend toward defects and deterioration and lack of permanency and of provisions that will give increased assurances of permanence. It should be noted, also, that in recent years a large amount of valuable research work on concrete and its properties has been carried on by numerous laboratories that has contributed knowledge of great value on the properties of concrete, research that is creditable in every way. Space will not permit enumeration of the agencies thus contributing, but they include governmental and state laboratories and college and private laboratories, one of the most fruitful being the Structural Materials Research Laboratory of the Portland Cement Association. The interest in this work is so keen and the opportunities so great that further contribution of great value may be confidently expected as time goes on.

It is hardly within the field of this address to deal with the vital element entering into concrete, the cement. It will not be out of place, however, to voice a general feeling that there is urgent need of research in this field and abundant opportunity for obtaining knowledge that will be of the highest advantage and usefulness in the control and improvement of the qualities and properties of cement, and also to express the belief that agencies competent to undertake this task will bring forth contributions of high value and usefulness.

I wish there were opportunity to relate more fully the accomplishments in research made in the field of reinforced concrete and to record the agencies and the personnel responsible for the work and to evaluate to a greater extent the influence of the results on engineering practice and on the public estimate of this material. I hope, however, that what has been said will lead you to feel that research has had an important influence in the development of reinforced concrete in this formative period, and that it is entitled to be thought worthy of comparison with the research that has been conducted on other engineering materials: The knowledge so contributed has added to the safety, utility, and economy of every form of construction. It has aided in establishing confidence in the general public estimation. In doing all this, it has exemplified the value of research in general in the promotion of the public welfare. And it may be stated with confidence that in recent years it has been recognized generally that research has become a strong, vital agency in the development of the industrial growth and the engineering activities of the country and that it is having a remarkable influence on the life of the nation. By his part in the development of engineering materials the testing engineer has more and more contributed a generous share to the nation's output of research. And may it not be said that the American Society for Testing Materials, with its sponsorship of research in its field and with the stimulation and inspiration it has given, has effectively aided the creation of useful knowledge, valuable and even vital to the life of the nation and its people. And we may confidently look forward to other and still greater accomplishment on this side of the Society's activities as time goes on.

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE

The Executive Committee offers the following report of general Society activities for the past year:

Membership:

Membership statistics for the past year are shown in the following table:

	1925 Annual Meeting	1926 Annual Meeting	Losses				Additions		Totals		
			Transfer	Resignation	Dropped	Death	Transfer	Election	Loss	Gain	Increase
Honorary Members	2	2	..	...	...	..	..	...	...	.....	...
Members	3635	3920	..	123	100	12	12	508	235	520	285
Junior Members	79	78	12	7	8	1	..	27	28	27	1[a]
Total	3716	4000	12	130	108	13	12	535	263	527	284

[a] Decrease.

The membership of the Society at the time of this annual meeting is 4000. The net increase in membership for the year now ending is 284, as compared with 235 for the year ending with the 1925 annual meeting and 241 for the year ending with the 1924 annual meeting. The number of new members elected during the year (535) compares very favorably with the records of preceding years. Quite a number of these new members have been secured through the efforts of the standing committees and others have become interested through extension of the Society's work into new fields. What is being done to stimulate healthy growth of the Society membership has been reported from time to time in the A.S.T.M. Bulletin. The interest of the standing committees and of the members individually has been very gratifying and the Executive Committee expresses its appreciation of their efforts, which are helpful in many ways, not the least being the constant widening of the circle of influence of the Society.

The Society has suffered the loss by death of thirteen members, among them being Guilliaem Aertsen, a Past-President of the Society and active along both technical and executive lines for many years. The names of the deceased members are:

Guilliaem Aertsen
Victor Angerer
A. T. Bradlee
W. H. Finley
Elbert C. Fisher
M. H. Freeman

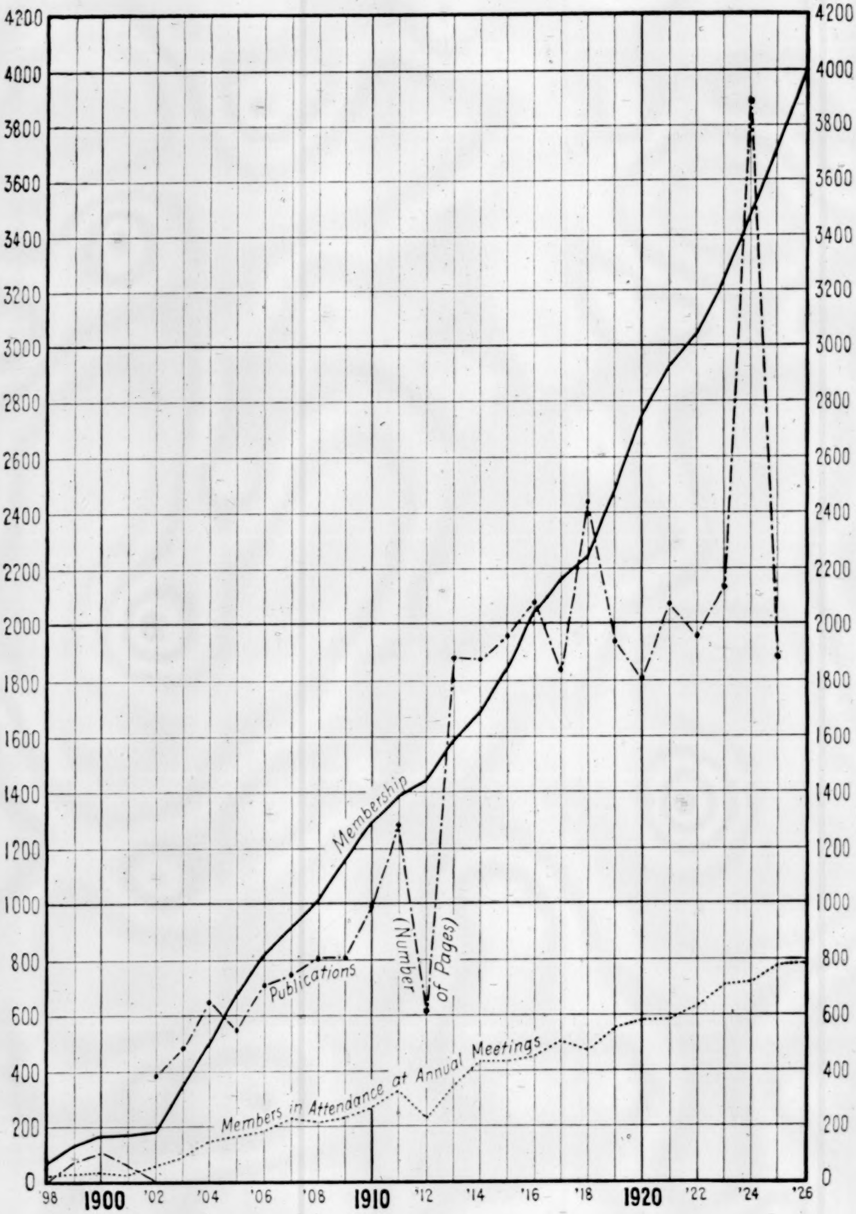

FIG. 1.—Membership and Publications Chart.

C. D. Gregg
Samuel Peacock
R. P. Schelly
M. N. Taber
I. H. Village
D. B. Wentz
H. B. Wiese

Membership growth since the organization of the Society is shown in Fig. 1.

Committees:

The committees are bringing before the Society this year many valuable reports. Since the last annual meeting there have been organized two new committees, namely, Committee B-4 on Metallic Materials for Electrical Heating and Committee D-18 on Natural Building Stones. Announcement of the formation of these two committees with a statement of the activities to which they are devoting their immediate attention was made in the A.S.T.M. Bulletin. The total number of standing committees is now 45. Of these 5 are not presenting reports this year, 4 have submitted formal reports of progress to the Executive Committee, and reports from the remaining 36 are announced on the program of this meeting. These reports comprise approximately 850 pages and include recommendations for revisions in 40 standards, adoption of 17 tentative standards as standard, acceptance of 54 proposed new standards as tentative, and proposed revisions in 52 tentative standards to be continued as tentative. Thus it is evident that substantial progress has been made by the Society this year in its program of standardization. There are at present 447 standards and tentative standards of the Society, and if the recommendations of the various committees are approved this number will become 497, an increase of 50.

There have also been organized during the year, upon the initiation of Committee E-9 on Correlation of Research, the following two committees: a Research Committee on Effect of Tin and Arsenic on High-Speed Tool Steels and a Research Committee on Yield Point of Structural Steel. Their formation is mentioned more fully in the report of Committee E-9.

In response to a request from Committee A-4 on Heat Treatment of Iron and Steel, the Executive Committee approved a suggested extension of the committee's activities by which it may engage in the preparation of recommended practices for heat treatment of particular objects.

The same committee during the year pointed out that the introductory section of the present recommended practices of the Society dealing with heat treatment, which was worded to agree with the committee's understanding of a ruling of the Executive Committee made in 1920, seems unduly restrictive and tends to limit the usefulness of the recommended practices:

> "This recommended practice is intended solely for guidance and is not to be construed as entering in any manner into specifications of the American Society for Testing Materials."

Consultation with the officers of Committees A-4 and A-1 on Steel resulted in approval by the Executive Committee of the following rewording of this section:

> "This recommended practice has been prepared for guidance in the (insert title of recommended practice). Its adoption by the Society is not to be construed as making the recommended practice a mandatory requirement of A.S.T.M. specifications for materials."

During the year two more group meetings of committees have been held, one at Cleveland, Ohio, October 27–29, 1925, and the second at Providence, R. I., March 17–19, 1926. Both meetings were most successful in every way, upwards of 15 committee and 42 sub-committee meetings being held at Cleveland, with a total attendance of 275; and 15 committee and 49 sub-committee meetings at Providence, with a total attendance of 350. The details of these meetings have been fully reported in the A.S.T.M. Bulletin. The Executive Committee wishes to encourage the continuance of these group meetings when they can be arranged to suit the convenience of a number of the Society's committees. It further seems desirable to continue, if possible, the plan by which the fall and spring meetings have been alternated between the West and the East.

Publications:

The regular publications during 1925 were the Proceedings, Supplement to the Book of A.S.T.M. Standards and the Year Book. A comparative statement of the volume of regular publications during the past three years is as follows:

	1923, PAGES	1924, PAGES	1925, PAGES
Proceedings	1689	2306	1416
Book of A.S.T.M. Standards	....	1219	....
Supplement to Book of Standards	126	....	117
Year Book (Membership List)	326	328	352
	2141	3853	1885

In addition, the Society published in 1925 the Book of A.S.T.M. Tentative Standards (876 pages), which is furnished to members upon order at special prices. This brings the total number of pages of bound publications issued since the last annual meeting, but not including preprints and reprints, up to 2761.

The A.S.T.M. Bulletin has been issued at approximately quarterly intervals and five circulars to members have been printed. Reprints of several committee reports have been published for committee use and for sale, the principal among them being the report of Committee D-2 on Petroleum Products and Lubricants, 66 pages (900 copies) and the report of Committee A-5 on Corrosion of Iron and Steel, 24 pages (500 copies). There was also published a special pamphlet in which were compiled the A.S.T.M. Specifications and Methods of Test for Textile Materials and certain information relating thereto abstracted from the reports of Committee D-13 on Textile Materials. This pamphlet comprised 70 pages and 1750 copies were printed. There has been a very steady demand during the year for copies of such special reprints as those of the Report of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete, the Symposium on Effect of Temperature on the Properties of Metals and the Symposium on Corrosion-Resistant, Heat-Resistant and Electrical-Resistance Alloys.

Proceedings.—Attention is directed to the fact that the 1925 Proceedings are considerably smaller in volume than those for either of the two preceding years. As explained in the report a year ago, it was necessary to reduce rather drastically the volume of technical papers and to some extent of committee reports, in order that the deficit incurred in publishing the large volume of Proceedings in 1924 could be liquidated. That this has been done may be seen from the report on finances given below, although the Executive Committee believes, as stated last year, that it is contrary to the best interests of the Society to have to decline the publication of worth-while data from our committees and from members in the form of papers on the plea that it has not the necessary funds.

During the year some consideration was given to a proposal of a modified plan of issuing the Society's Proceedings by which members would receive after the annual meeting final reprints, complete with discussion, of such committee reports and papers as they requested and that bound volumes of the Proceedings would be furnished to the members only upon order and upon payment of a charge to cover cost of reprinting and binding. An analysis of this plan indicated that it has little if any advantage from the point of view of financial saving and the Executive Committee felt that the advantages of the present method of publishing the Proceedings far outweigh any small possible savings in expense of publication. It has accordingly been decided to adhere to the present method of publication.

Book of Standards.—So rapidly is the number of standards increasing that by 1927, the year of publication of the next edition of the Book of A.S.T.M. Standards, there will be upwards of 325 standards which will occupy, it is estimated, at least 1500 pages—far too voluminous for convenient publication in a single volume. Considering weight, convenience in handling, permanency of binding and other factors, the practicable limit of binding the standards in one volume has been reached with the 1924 edition of 1219 pages. The paper now used is as light in weight as can safely be used unless the so-called India papers are adopted, and these are not considered to be suitable for the Book of Standards.

In consultation with the Committee on Papers and Publications, two plans of publishing the Book of Standards have been carefully analyzed: first, the "loose-leaf" form with binder; and second, publication in two bound parts. After full consideration of the "loose-leaf" plan of publication, it was decided not to adopt it. The advantages of this plan are outweighed by the serious disadvantage of making it incumbent upon the members to keep their files of standards up to date—a difficulty that would increase with increase in the number of standards. In fact, so much difficulty has been experienced with this phase of the plan that two large national engineering societies, engaged in extensive standardization work of a nature similar to ours, have recently abandoned it and adopted the permanently bound publication. The greater convenience to our members of the bound publication and the assurance at all times that they have on file the latest standards are determining factors, in the opinion of the Executive Committee.

The division of the Book of Standards into two parts is a logical step forward from the present plan of publication, involving the least modification of well-established publication policies. Of the possible methods of dividing the standards, that of publishing standards relating to metals in one part and those relating to non-metals in the second part is by far the best. It will result in volumes of approximately equal size and will require a minimum of cross-referencing. It is probable that with this division and under the plan of distribution recommended below, many members will wish to secure only one part of the Book of Standards, since their interests may be exclusively in the field either of metals or non-metals; and for those members who wish to have the complete set, it is not believed that it would be considered any more of a disadvantage to have the Book of Standards in two parts than the Proceedings as at present.

In considering a plan of distribution of the two parts for recommendation to the Society, the Executive Committee has taken into account two important factors: (1) the increased expense of binding two parts, which however may be partly offset by a decrease in the number of copies of the individual parts required; and (2) the difficulty of continuing to furnish *every* member of the Society with *all* the standards at the present dues. Thus, in the period of ten years since 1916, when the dues were fixed at $15, the volume of standards has grown from about 600 to 1500 pages, or two and one-half times. In the same period the volume of Proceedings has increased from about 1100 to 1800 pages, on an average; and printing costs have advanced 60 per cent. The Executive Committee has felt that it has been only a question of time before some adjustment of this situation would be necessary. With these considerations in mind, the Executive Committee wishes to make the following recommendations to the Society:

1. That beginning with the 1927 edition, the Book of A.S.T.M. Standards and the Supplements thereto, be published in two parts: Part I covering Metals and Part II covering Non-Metals;
2. That the policy be adopted of furnishing to each member either Part I or Part II of the Book of Standards, in cloth binding, and Supplements thereto, as he may elect; and that members desiring the other Part in cloth binding, with Supplements, may secure a copy for the sum of $2.00;
3. That the sales price to non-members shall be $7.50 for either Part in cloth binding and $14 for both Parts, in each instance with corresponding Supplements;
4. That the price to members for *extra* copies of the Book of Standards, including Supplements, shall be $5.00 for either Part and $9.00 for both Parts, in cloth binding;
5. That the usual increases in price for copies in half-leather binding shall apply; and
6. That the sales price of individual Supplements shall be fixed each year by the Executive Committee as at present.

The prices recommended have been determined after the best analysis possible of the prospective demand for the two Parts of the Standards under this plan of distribution and sale. In particular, the recommended charge of $2.00 to the members for the second Part, which it will be remembered is spread over a period of three years in view of the triennial publication of the Book of Standards, is as low as it can possibly be made without entailing a financial loss to the Society.

Book of Tentative Standards.—There has been a steadily growing demand for the Book of Tentative Standards. The Committee on Papers and Publications has advised the Executive Committee that it believes the importance of this publication and the fact that it is the only publication containing all of the tentative standards for a given year points to the desirability ultimately of publishing the volume as a regular publication, furnishing it to all members of the Society, in which case the new and revised tentative standards now published in Part I of the Proceedings could be omitted. The Executive Committee agrees in principle with this plan but does not believe that the net expense of establishing the Book of Tentative Standards as a regular publication, which would be about $1.50 per member, is warranted at this time. It has accordingly been decided to continue for the present the existing plan of publishing the volume. It is possible that a plan may be developed for selective distribution of the Book of Tentative Standards on a basis similar to that recommended for the Book of Standards, but the Executive Committee believes it advisable to get the Book of Standards permanently established upon the proposed new basis before considering a similar change in the Book of Tentative Standards.

In consideration of the payment of an entrance fee, the establishment of which is recommended later in this report, the Executive Committee recommends that new members of the Society as they qualify for membership be given a copy of the current Book of Tentative Standards. New members at present are somewhat at a disadvantage in not having ready access, without purchase, to back numbers of the Proceedings containing tentative standards that have been standing for some time.

During the year an analysis was made respecting the number of years the present tentative standards have been standing as such either with or without revision, in pursuance of which the Executive Committee has voted to require standing committees to state to it or to the Society in their annual reports the reasons for continuing a tentative standard in that status for three or more years without revision and without recommendation for advancement to standard. It is felt that all proper latitude must be given to the standing committees in the matter of retaining tentative standards in that status, but that standing committees should periodically review the tentative standards in their charge and give the reasons for their continuance as such.

A.S.T.M. Bulletin.—With the April 30 issue, the A.S.T.M. Bulletin has entered the sixth year of publication. An outgrowth five years ago of the then only means of communication with the members,—the Circular Letters issued at irregular intervals,—the Bulletin was designed to establish closer contacts with the members and to keep them more frequently and intimately informed of the Society's activities between annual meetings, especially the work of the committees. An incidental object was to provide a means of greater publicity of Society affairs in the technical press. These purposes have been fully realized and the Bulletin has found an important place among the Society publications. There is a constantly increasing flow of material for the Bulletin,—committee activities, the group meetings, general Society affairs, our work with the American Engineering Standards Committee, cooperative relations with other organizations,—all of which is "news" that should be disseminated fairly promptly among the members. To do this effectively requires either an increase in the size of the individual numbers of the Bulletin or issuing the Bulletin at more frequent intervals; either, of course, involves added expense. The Executive Committee believes that more frequent publication of a smaller Bulletin is the more effective method of expanding this service.

A recommendation to this effect was made about a year ago by the Special Committee on Promotion of Usefulness of the Society's Work but the cost was more than could be met under the present budget and the plan of quarterly publication was continued for this year. In the meantime the Executive Committee has decided to make the pages of the Bulletin available to certain classes of advertising, with the expectation that in this way the Bulletin may be placed substantially upon a self-sustaining basis and that the desired expansion of the Bulletin service can be accomplished without drawing too heavily upon the main sources of income of the Society. Advertising of the following classes only will be accepted: (1) that of manufacturers and suppliers of testing machines, testing apparatus and similar equipment, and of testing laboratories; (2) that of book dealers and publishers of technical books, especially those relating to materials; and (3) professional cards of consulting engineers, metallurgists, chemists, testing engineers and testing laboratories. Suitable restrictions have been placed upon the character and position of advertising accepted, as announced in the April issue of the Bulletin with which this advertising policy was inaugurated.

Report on Finances:

The annual statement of the finances of the Society follows in the form of the report of the auditors for the fiscal year January 1, 1925, to December 31, 1925.

REPORT OF THE AUDITORS FOR THE FISCAL YEAR JANUARY 1, 1925, TO DECEMBER 31, 1925

JOHN HEINS AND CO.
CERTIFIED PUBLIC ACCOUNTANTS

PHILADELPHIA, January 6, 1926.

AMERICAN SOCIETY FOR TESTING MATERIALS,
MR. C. L. WARWICK, *Secretary-Treasurer*,
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 31, 1925, having previously made a similar audit and report for the preceding six months ended June 10, 1925, and at both audits found the accounts to be correct and to be in their usual excellent condition.

We submit balance sheet as of December 31, 1925, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the last six months as also for the six months ended June 10, last, as reported in ours of June 19, last, and found the same to be correct.

We have verified by actual inspection and count the securities as listed on the Balance Sheet.

Respectfully submitted,
(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1925

ASSETS			
Current Funds		$ 5,041.21	
Investments (see page 13)		24,023.60	
Accounts Receivable:			
For Publications	$1,733.20		
Members for 1925 Dues	2,160.00		
Members for Binding	53.00		
		3,946.20	
Furniture and Fixtures		3,808.45	
			$36,819.46
LIABILITIES			
Publications paid for in advance	$81.50		
Members dues paid in advance	949.42		
Members binding paid in advance	6.00		
		$1,036.92	
Life Membership Fund	$1,805.20		
Reserve for Publications	4,368.37		
Surplus	29,608.97		
		35,782.54	
			36,819.46

MISCELLANEOUS FUNDS

In addition to the above funds the Secretary-Treasurer has on hand the following funds, partly invested as shown on page 13:

Committee A-5 on Corrosion of Iron and Steel	$10,303.42	
Committee C-1 on Cement	818.17	
Committee C-9 on Concrete and Concrete Aggregates	622.94	
Committee C-10 on Hollow Masonry Building Units	210.76	
Committee D-1 on Preservative Coatings	32.44	
Joint Committee on Investigation of Phosphorus and Sulfur in Steel	105.57	
		$12,093.30

RECEIPTS AND DISBURSEMENTS

JANUARY 1, 1925, TO DECEMBER 31, 1925

Cash on hand January 1, 1925			$282.06
RECEIPTS			
Current dues	$54,534.89		
Past dues	901.85		
Advance dues	949.42		
Life Membership dues	205.20		
Total Dues		$56,591.36	
Sale of Publications:			
Separate Standards	$4,839.85		
Book of Standards	7,461.12		
Book of Tentative Standards	6,203.57		
Proceedings	4,319.84		
Miscellaneous (including special reprints)	10,806.62		
Total Sale of Publications		33,631.00	
Binding (Members)		842.00	
Authors' Reprints		497.65	
Sale of Certificates of Membership		50.00	
Interest on deposits and investments		2,148.56	
Accrued interest and premium		514.52	
Excess remittances		40.00	
Investments matured or sold		10,000.00	
For account of Committee D-9		1,501.24	
Contributions from members of standing committees to Entertainment Fund, Annual Meeting		639.00	
Seaview Golf Club charges, reimbursed by members		420.70	
Miscellaneous		17.48	
Total Receipts		$106,893.51	106,893.51
Carried forward			**$107,175.57**

Brought forward			$107,175.57

DISBURSEMENTS

Publications:			
Year Book	$3,230.55		
Proceedings	19,833.46		
Book of Standards and Supplement	1,625.62		
Book of Tentative Standards	2,895.99		
Preprints	2,559.42		
Bulletins and Circulars to Members	2,419.38		
Separate Standards	2,122.20		
Miscellaneous (including special reprints)	7,406.29		
		$42,092.91	
Salaries		23,753.90	
General office expenses		5,251.62	
Expenses, Standing Committees		1,950.95	
Expenses, Annual Meeting		2,252.84	
Traveling expenses—Executive, Nominating, Correlation of Research and Promotion of Usefulness Committees		826.30	
Rent and insurance, storage rooms		321.00	
Rent, headquarters		2,400.00	
Headquarter's maintenance		195.26	
Furniture and Fixtures		558.71	
Girard Trust Co., repayment of loan and interest		4,008.00	
Certificates of Membership		5.75	
American Engineering Standards Committee		1,500.00	
Annual Tables of Constants and Numerical Data		100.00	
Investments		14,178.16	
Accrued interest and premium		752.02	
Seaview Golf Club (see Receipts)		420.70	
Refund of excess remittances		40.00	
Contribution to U. S. National Committee, International Electrotechnical Commission		250.00	
For Account of Committee D-9		1,251.24	
Miscellaneous		25.00	
Total Disbursements		$102,134.36	102,134.36
Balance, Current Funds, December 31, 1925			$5,041.21*

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* Balance accounted for as follows:

Cash on hand	$4,891.21	
Liberty bonds purchased from current year's receipts	15,000.00	
	$19,891.21	
Less checks drawn but not paid against cost of Proceedings	14,850.00	
		$5,041.21

INVESTMENTS

SOCIETY FUNDS

$13,500 U. S. Liberty Loan Bonds, 4th 4¼'s	$12,983.53	
1,600 U. S. Liberty Loan Bonds, 4th 4¼'s, held for Life Membership Fund	1,533.18	
1,000 U. S. Liberty Loan Bonds, 4th 4¼'s, reserve for Index to Proceedings	1,005.47	
3,300 U. S. Liberty Loan Bonds, 4th 4¼'s, reserve for 1927 Book of Standards	3,362.90	
3,000 P. R. R. Equipment Bonds, 6's due 1933	3,052.56	
2,000 Michigan Central Equipment Bonds, 6's, due 1932.	2,085.96	
		$24,023.60

COMMITTEE FUNDS

$9,500 U. S. Liberty Loan Bonds, 4th 4¼'s		$9,681.09
Committee A-5	$9,171.56	
Committee C-1	509.53	
		9,681.09

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1921–1925, INCLUSIVE

Fiscal Year	Assets					Liabilities		
	Current Funds	Investment	Accounts Receivable	Advance Rent and Furniture and Fixtures	Total	Accounts Payable[a]	Reserve for Publications	Surplus and Life Membership Fund
1921	$3 819.07	$17 608.09	$5 218.35	$5 121.34	$31 766.85	$770.00	....	**$30 996.85**
1922	3 495.03	20 660.65	5 242.65	4 293.09	33 691.42	663.25	$3 894.61	**29 133.56**
1923	5 139.72	23 660.65	5 202.16	3 598.49	37 601.02	467.99	6 894.61	**30 238.42**
1924	282.06	19 845.44	6 909.42	3 672.90	30 709.82	4 797.31	495.94	**25 416.57**
1925	5 041.21	24 023.60	3 946.20	3 808.45	36 819.46	1 036.92	4 368.37	**31 414.17**

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[a] These sums represent dues and publications paid in advance and do not include any unpaid bills except for **1924**, a loan of $4000 from the Girard Trust Company.

The surplus on December 31, 1925, was $31,414.17, including the Life Membership Fund of $1805.20. In addition there is the sum of $4368.37 set aside as a reserve fund for publications; $3362.90 representing funds set aside from 1925 income against the cost of publishing the 1927 Book of Standards, and $1005.47 representing moneys set aside from 1924 and 1925 income against the cost of publishing the collective Index of Proceedings for 1921 to 1925, inclusive. At the end of the report is given the comparative financial condition of the Society at the close of the past five fiscal years.

Attention is called to the receipts from publication sales of $33,631.00—by far the largest ever realized from this source. Sales of the separate standards and of the Book of Standards were exceptionally active, reflecting the continually increasing use of the Society's specifications. The sales of a number of special reprints resulted in a considerable income. The income from sales of publications was an important factor in completely liquidating the deficit of the preceding year and making it possible to close the year with a substantial balance. Of this balance, $2000 has been permanently invested and $1700 added to the reserve for publication of the 1927 Book of Standards.

Inventory of Publications in Stock:

In the foregoing financial analysis no account has been taken of the assets of the Society in the form of publications in stock. The inventory on May 15, 1926, may be summarized as follows:

	NUMBER OF COPIES
Proceedings	4 849
1924 Book of Standards	1 314
Index to Proceedings (Vols. I–XII, incl.)	556
(Vols. XIII–XX, incl.)	717
Reports of Committee D-1 (1903–1914, incl.)	270
Reprints of 254 standards (approximate)	15 000
Special reprints for general sales (approximate)	5 000

Increasing the Financial Support of Society Activities:

In its report a year ago the Executive Committee discussed the need of increasing the financial support of the Society's work, in order that the Society might be better able to publish the constantly increasing volume of important data on properties of materials that is being brought to it in the form of reports by the standing committees and of technical papers by the members. Such data are of much value to many industries and it is perhaps one of the most important functions of the Society to publish them. During the year this situation has been studied by the Executive Committee, with the result that the committee is prepared to make two recommendations to the Society:

1. That there be established a Fund to which annual contributions will be accepted from the industries (both producing and consuming materials) that benefit by the work of the Society. The Fund is to be considered primarily as a capital investment, the income of which will be budgeted for current use as decided by the Executive Committee.

2. That there be established an entrance fee of $10 for Members and $5 for Junior Members, and a transfer fee from one grade of membership to another equal to the difference in entrance fees, the sums thus realized in so far as possible being applied to the above-mentioned Fund.

Needs for Additional Income.—In reaching this decision the Executive Committee first considered the specific needs for additional income under three headings: Publications, Research and Increase of Office Personnel.

Mention has previously been made of publication requirements. It is pertinent to observe that the rapid growth of standardization activities in many industries, the expansion of our committee work into new fields, the constant development of new materials and new tests, and the stimulation of research among our committees that will result from the activities of Committee E-9 on Correlation of Research, will all make demands upon the publication facilities of the Society that are certain to increase with time, and more rapidly—judging from the experience of the past three years—than our normal increase in yearly income can take care of.

Generally speaking, funds for specific research can and should be secured directly from those industries that benefit from the results of the particular investigation, and this plan has been successfully followed by a number of our committees. It is believed, however, that as this side of the Society's work develops there will be researches of a type that may not so readily command the direct financial support of industry but will nevertheless have important technical and scientific value, and to which funds set aside for this purpose might very properly be applied.

The work that now centers in the office of the Society has grown so rapidly in the past two or three years that increases in the staff are urgently needed. Needs incident to membership growth can and have been met from increase in current income. Other matters of much importance to the proper development of Society activities have or should be developed more rapidly than can possibly be accommodated by normal current income. Of these the most important are the editing required in our growing publication work; the secretarial and editorial work involved in the activities of Committees E-1 on Methods of Testing, E-8 on Nomenclature and Definitions and E-9 on Correlation of Research, which because of their correlative and "clearing-house" nature are necessarily centered in the Secretary-Treasurer's office; the development of our cooperative relations with the American Engineering Standards Committee and our responsibility for sponsoring the formulation of American Standards for materials; the development of our group committee meetings; and the carrying out of various plans for promoting the usefulness of the Society's work. Several of these features require the placing of another technically trained man upon the staff, as well as additional stenographic and clerical assistants.

The Executive Committee has estimated that these needs, as they will develop within the next few years, will require an increase in annual income, over and above the normal increase due to membership growth, of approximately $8000.

Various Sources of Additional Income.—The Executive Committee has considered a number of possible sources of income in addition to the two that have been recommended. Despite the decreased purchasing power of the dollar in the ten years since the annual dues have been $15,—a decrease that is reflected, for example, in an increase of 60 per cent in printing costs over that period and of course affects every activity of the Society,—the committee does not favor an increase in the membership dues, which is one of the obvious sources of further income. It has been possible for the Society, by reason of the increase in recent years in receipts from sales of publications (note the divergence of the curves in Fig. 2 marked "Total Receipts" and "Receipts from Dues"), to furnish to the members a constantly *increasing* volume of publications without an increase in dues. While this is no longer possible with respect to the distribution of the Book of Standards and recommendations have been made earlier in the report to meet this situation, the Executive Committee is convinced that it is not to the best interests of the Society to increase the dues at this time. It is very desirable that the conditions of membership, particularly for individuals, be made as favorable as possible in order that the influence of the Society may be widely extended and our publications and standards obtain a maximum distribution. Contributions from industries towards specific investigations and income from foundations established to aid research are sources of income of which advantage should be taken where possible, but in general cannot be counted upon to meet needs of the kind outlined above. The possibility of advertising as a source of income, perhaps with the establishment of monthly proceedings or a journal, was also conconsidered but was not viewed favorably. The Executive Committee is opposed to the use of advertising in the bound publications as a source of income, nor does it believe that the Society should consider at this time so radical a change in policy as would be involved in the publication of a society journal. As stated earlier in the report, it has opened the pages of the A.S.T.M. Bulletin to advertising as a means of expanding the Bulletin service. The holding of an exhibit in connection with technical society meetings has proved to be an important source of income for several societies, but this is not recommended. An exhibit in connection with Society meetings, even were it considered desirable from other viewpoints, would probably have to be confined logically to the display of testing apparatus and as such would not assume the large proportions that have made other exhibits profitable sources of income.

The committee believes that the establishment of the proposed Fund is the best solution of this problem. It was pointed out in the Presidential Address of Mr. Farmer a year ago that industry, both consuming and producing materials, profits directly by the work of our organization to an extent far in excess of the present costs to industry. The Society has served the industries of the country very materially in the establishment of standard specifications and methods of test and in the promotion of knowledge of engineering materials, and it is a logical step to seek the further help of industry to enable the Society to continue and increase that service beyond the possibilities of the present income. Consideration was given to the possibility of creating a separate class of company, corporation, firm or association membership with increased dues. After looking into this plan it was thought best to place the whole proposition upon a voluntary rather than a compulsory basis. In other words, there are many smaller companies and firms to which the work of the Society is not of the same importance and value that it is to larger companies, and it seemed best to have simply the one class of membership with dues of $15 and to seek the voluntary annual contributions to the Fund of those companies, firms, corporations and industrial associations sufficiently interested in the welfare of the Society to see such a Fund built up to strengthen its work.

It is the thought of the Executive Committee that there should be a maximum limit placed upon the annual contribution to the Fund from any one company, firm, corporation or association. Contributions of the order of $50 to a maximum of $250 have been considered in discussing this plan.

The entrance and transfer fees recommended are a logical and justifiable source of income and upon the basis of the present rate of membership growth will realize annually a sum of $4000 to $5000.

In justification of an appeal to industry for the establishment of the Fund, the Society can point to many years of successful, conservative management, for the past eight years under the budget system by which income from all sources is conservatively estimated at the beginning of the fiscal year and disbursements for that year are fixed to keep within the estimated income. Only once in the last ten years has a deficit been incurred, namely, in 1924 due to unusual publication expense, and this was liquidated the next year by drastically curtailing the publications of the Society. The present sound financial condition of the Society is seen from the balance sheet of the accompanying auditors' report. It is of interest to refer to the accompanying Fig. 2, upon which are shown for the past ten years the total annual receipts and disbursements, the receipts from annual dues and the steady growth of membership. It has been possible since 1916 to build up gradually, out of the favorable balances between receipts and disbursements, a surplus or permanent reserve against contingencies, which on December 31, 1925, was slightly over $20,000. It is significant that the ratio of receipts from dues to total receipts has steadily fallen from 80 per cent in 1916 to about 60 per cent in 1925. In other words, the Society has become increasingly dependent upon receipts from sales of publications to enable it to carry on its activities. The Society is in an excellent position to administer funds for publication and research. Such funds raised by our committees have been administered with a minimum of overhead expense and every dollar contributed by industry to the Society for investigations and publica-

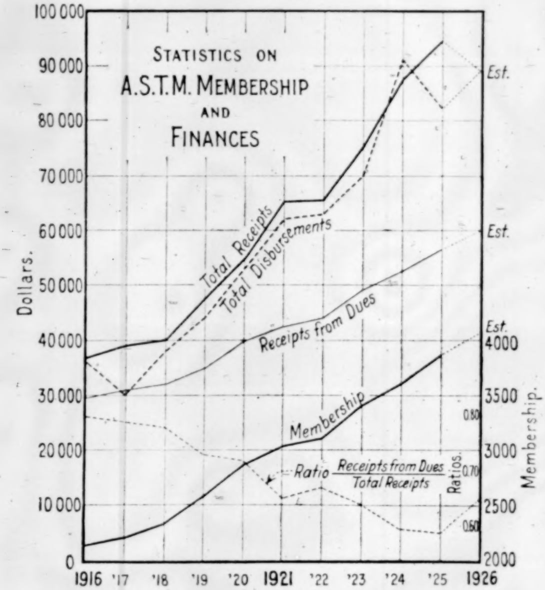

FIG. 2

tions has been used for the purpose contributed. The same assurance can be given to all contributors to the proposed Fund.

The fixing of entrance and transfer fees requires an amendment of Article VII of the By-laws, which is formally proposed in a later section of the report.

Promoting the Usefulness of the Society's Work:

During the year, the Special Committee on Promotion of Usefulness of the Society's Work, under the chairmanship of Vice-President J. H. Gibboney, has continued its study of means by which the usefulness of the Society's work may be extended in various ways. It is still discussing some important matters concerning which it has not reached conclusions, as, for example, means by which the work of the Society may be made more widely known to the buying and selling public and by which the small consumer especially may more greatly benefit by the standardization work of the Society than is apparently the case at present. With respect to some other matters, however, it has made definite recommendations of policy to the Executive Committee. Most of these have been approved and are being put into effect in appropriate ways. These are presented to the Society and discussed in the following paragraphs.

Publicity.—Considerable progress may be recorded in securing publicity of A.S.T.M. activities between annual meetings. The group committee meetings held in Cleveland and Providence were quite fully reported in the technical press. Several news releases were prepared during the year for the use of the technical journals. It is planned to develop the latter feature more fully during the coming year as conditions permit, and ultimately to utilize this feature in connection with more frequent publication of the Bulletin.

Through the interest of one of the members of the Executive Committee it has been possible to secure without expense the services of a publicity expert to take charge, under the general direction of the Secretary-Treasurer, of publicity of the annual meeting in the daily press. There is much that transpires at the annual meeting that has distinct news value and an appropriate account of the Society's work in the press of the country is to be desired. The first effort in this direction was made on a small scale in connection with the annual meeting a year ago and the result justifies the efforts on a larger scale this year. The reporting of the annual meeting in the technical press will be handled as in past years.

Technical Schools.—A definite effort has been made to extend knowledge of the Society's work among the 162 engineering schools of the United States and Canada. A survey last fall showed that 94 of these schools were represented either through membership of the school or of some department or through personal membership of one or more members of the faculty. Under the direction of the Membership Committee the heads of the various engineering departments of the remaining 68 schools were addressed, the work of the Society explained, their interest invited, and invitations to membership extended. In this and other ways 13 of these schools have become connected with the Society, bringing the total to 107. In addition, eleven members of faculties of other schools have since joined the Society, and our classification of membership now shows 246 members in the "educational" group, compared with 222 about a year ago. In view of the importance of contact with technical schools, the growth of our membership in this direction is gratifying.

Student Membership.—During the year consideration has been given by the Special Committee to a suggestion made by Committee A-4 on Heat Treatment of Iron and Steel that steps be taken to interest engineering students in Society membership, possibly through creating a class of Student Membership. In considering this suggestion the opinions of the heads of a number of engineering schools were obtained, with the result that there was practically unanimous agreement upon the desirability of interesting engineering students in the work of the Society through the establishment of this grade of membership. The whole purpose, of course, is the desire to bring interested engineering students into more intimate contact with the field of materials and to give them an insight into how materials are being studied and applied in industry. Some familiarity on the part of the student with our work of standardizing specifications and methods of test will be helpful to him as a student; and by gaining his interest in his undergraduate days we would hope to have him maintain his connection with the Society after graduation if he entered a field that brought him into contact with the study and use of materials. It is in a way a matter of fundamental importance that the coming generation of engineers should be familiar with our activities in the field of materials and that they be prepared in their later engineering experiences to make use of and support our work.

Accordingly the Executive Committee recommends the establishment of the grade of Student Member, to which shall be eligible juniors, seniors and graduate students in technical schools of recognized standing, and students not over 25 years of age engaged in technical studies in an apprentice course or night school. It is proposed that Student Members shall pay annual dues of $3.00 and shall have such rights and privileges as may be determined by the Executive Committee. It is believed that Student Members should receive the Book of A.S.T.M. Standards and preprints of reports and papers issued prior to the annual meeting, but not the annual Proceedings. They should also receive the Year Book and the Society Bulletin, and should have the privilege of purchasing Society publications at the special prices to members. Such memberships, of course, can be carried only at a loss financially, but the Executive Committee believes that this is much more than offset by the desirable educational features of the plan.

The necessary amendments of the By-laws to establish this class of membership are proposed in a later section of the report.

Survey of Extent of Use of A.S.T.M. Standards.—The survey of extent of use of the Society's standards conducted during the year by questionnaire among the standing committees has been practically completed and the results have been analyzed in the Secretary-Treasurer's office. Only a few committees have been able, apparently, to give very explicit information regarding their knowledge of the use of the Society's standards but many of the committees have made interesting general statements respecting the use as a whole of the group of standards under their jurisdiction. While not in any sense complete, the information obtained will prove exceedingly helpful in efforts to promote greater use of the Society's standards in certain fields. The importance of the data thus obtained has indicated the desirability of assembling this and similar information from other sources in card index form so there will be gradually built up a fairly complete reference file on this subject, and this is being done.

In this connection the National Directory of Commodity Specifications issued during the year by the U. S. Government shows that the Society's standards, particularly its methods of test, are very widely recognized.

Certification of Conformity with A.S.T.M. Standards.—Among the various means that have been considered by the Special Committee for increasing the usefulness of the Society's standards to the smaller users of materials who do not have ready access to testing facilities, is that of in some way identifying the various products and materials with the fact of their conformity with A.S.T.M. standards. Two committees of the Society, C-7 on Lime and C-11 on Gypsum, have been considering the adoption of a plan by which shipments of those products conforming to A.S.T.M. specifications would be so identified by a suitable tag, reading somewhat as follows, using the wording under consideration by the Committee on Gypsum:

"The contents of this package, manufactured by the . . . . Company, when it left the mill complied with the requirements of the standard specifications of the American Society for Testing Materials for this gypsum product."

It will be noted that this is a statement made on the responsibility of the manufacturer and not in any sense a guarantee by the Society. The Executive Committee believes that this plan holds considerable promise in its application to a variety of materials and wishes to encourage its adoption by various industries where feasible.

In this general connection the Special Committee, at the request of the Executive Committee, considered the Certification Plan of Promoting the Use of Specifications that has recently been advanced by the Bureau of Standards, by which in brief manufacturers would file with the Bureau a statement that they are willing to certify to the purchaser of their commodity, when purchased under Federal Specifications, that the commodity conforms to the requirements of those specifications. The Executive Committee was asked by the Bureau of Standards to comment on this plan and further to consider a suggestion advanced by the Bureau that this plan of certification be adopted by the Society as applying to its specifications, as well as by other organizations that promulgate specifications. A study of this plan revealed very general agreement upon its merit in principle. Plans somewhat similar are already followed by a number of manufacturers who will furnish certificates upon request of the consumer. It is supported by considerable success among several associations and private organizations. In the opinion of the Executive Committee, however, the application of this plan by the Government on the scale proposed should be made only in the case of nationally recognized standards and not merely with respect to Federal specifications as such or to the specifications of any other society as such. It was felt that if each specification-making body or organization were to follow the plan as recommended, so that manufacturers would be expected to tell a number of different bodies that they will furnish certificates to purchasers indicating conformity of their materials with a number of different specifications, the plan will confuse rather than help the small user, who in general is unfamiliar with specifications and cares little about their details and who will wonder why there is not more uniformity in specifications. Accordingly it seems important to stress the prime importance of agreeing upon truly national standards. It is probable that a considerable number of the Federal Specifications for such products as food, clothing and miscellaneous supplies are already recognized as national standards. In the case of engineering standards, however, and specifically those in which our Society is interested, namely, materials, the American Engineering Standards Committee is the recognized clearing house for the establishment of American Standards and it is thought to be in the interest of the whole standardization movement to have the certification plan apply only to such nationally recognized standards.

After full discussion in both the Special Committee and the Executive Committee, the views of the Executive Committee were expressed in the following resolution:

> "RESOLVED
>
> "That the Executive Committee endorses the certification plan in the interest of extending the value of standards and the usefulness of standards to consumers, especially those having no facilities for inspecting and testing.
>
> "That the Executive Committee believes such a certification plan should be applied only to nationally recognized standards in order to avoid multiplicity of certifications.
>
> "That in so far as engineering standards are concerned, the Executive Committee urges recognition of the American Engineering Standards Committee as the medium for establishing American Standards and that the certification plan be applied only to such standards."

Proposed Amendments of the By-laws:

The following amendments of the By-laws are proposed in order to establish the entrance and transfer fees recommended earlier in this report and to establish the class of Student Member also previously recommended. These purposes will be accomplished by the amendment of Article I, Section 1, the adoption of a new Section 4 of Article I, the amendment of Article VII, Section 1, and the adoption of a new Section 2 of Article VII, all as proposed below.

In addition two other changes are recommended. It is proposed by amending Article I, Section 2, as indicated, to make it possible for a person less than 27 years of age to have the status of Member rather than Junior Member if he desires to pay the difference in dues. It is also proposed to take advantage of the opportunity afforded by these proposed changes in the By-laws to recommend the omission of Article VII, Section 2, relating to membership in the International Association for Testing Materials, since that Association is no longer in existence.

Following are the proposed amendments:

ARTICLE I. MEMBERS AND THEIR ELECTION

Section 1.—Amend to read as follows by the insertion of the italicized words:

"The Society shall consist of Members, Junior Members, *Student Members* and Honorary Members."

Section 2.—Amend to read as follows by the omission of the words in brackets:

"A Member shall be a person [not less than twenty-seven years of age], or a corporation, a firm, a technical or scientific society, a teaching faculty or a library, proposed by two members and elected by the Executive Committee."

Section 4.—Add a new Section 4 as follows, renumbering the remaining sections of the article:

"*A Student Member shall be a Junior, Senior or Graduate Student in a technical school of recognized standing, or a student not over twenty-five years of age engaged in technical studies in an apprentice course or night school, proposed by a member of the faculty and elected by the Executive Committee.*

"*A Student Member shall have such rights and privileges as may be determined by the Executive Committee and he shall not be eligible for office. His status shall be changed to that of Junior Member or Member upon severance of his connection with the technical school, apprentice course or night school.*"

ARTICLE VII. DUES

Section 1.—Amend to read as follows by the addition of the italicized words and the omission of the word in brackets:

"The fiscal year shall commence on the first *day* of January. The annual dues shall be $15 for Members, [and] $7.50 for Junior Members *and $3 for Student Members,* payable in advance. Honorary Members shall not be subject to dues."

Section 2.—Strike out this section, which reads as follows:

"Members or Junior Members holding membership also in the International Association for Testing Materials shall pay annually, in advance, the additional sum of $4, the fiscal year of the International Association beginning on the first of January, which sum shall be transmitted by the Secretary-Treasurer to the International Association."

Add the following new Section 2:

"*The entrance fees, payable on admission to the Society, shall be $10 for Members and $5 for Junior Members. The transfer fee, payable upon transfer from one grade of membership to another, shall be the difference between the corresponding entrance fees; provided that the payment of such transfer fee shall not be required of any Junior Member holding membership at the date of adoption of this section.*"

As required by the By-laws, these amendments were printed and mailed to the members of the Society in advance of the annual meeting. The Executive Committee recommends that they be approved at this meeting and referred to letter ballot vote of the Society for adoption.

Dudley Medal and Marburg Lecture:

The Dudley Medal and Marburg Lecture, authorized at the annual meeting a year ago, are in course of establishment. A special committee on Medal and Lecture Fund under the chairmanship of the President is engaged in raising the required sum of $7500 to establish these two features and it hopes to report at this meeting that the entire sum has been raised. As already announced to the members in the A.S.T.M. Bulletin, the Edgar Marburg Lecture is being instituted at this annual meeting, the Executive Committee having selected as the first Lecturer our Past-President and Honorary Member, Arthur Newell Talbot. The technical papers presented at this annual meeting will be reviewed for award of the Dudley Medal at the annual meeting next year.

Research in Materials:

The development of research in materials under the auspices of the Society and the study of means by which our activities in the promotion of knowledge of engineering materials may best be advanced, is going forward steadily under the guidance of Committee E-9 on Correlation of Research, organized primarily for that purpose. The activities of this committee as reviewed in its annual report will repay the study of our members, expecially as showing how much research in materials is now being carried on under the sole or joint auspices of the Society.

This is a forward-looking movement, the importance of which to the Society can hardly be overestimated.

Agreement to License Manufacture of Union Colorimeter:

The Society has executed a formal agreement with the Sinclair Refining Co., owners of the patent for the Union Colorimeter, by which that company agrees to grant licenses for the nominal sum of $1.00 to manufacturers of scientific instruments, approved by the Executive Committee, to manufacture and sell the Union Colorimeter. This instrument was accepted as tentative in 1923 upon the recommendation of Committee D-2 on Petroleum Products and Lubricants for use in determining the color of lubricating oils, and the specifications for the instrument are embodied in the present Tentative Method of Test for Color of Lubricating Oils by Means of Union Colorimeter (D 155 – 23 T). Committee D-2 was in close touch with the steps taken to develop this instrument and its adoption by the committee was based upon an understanding with the Union Petroleum Co., then owners of the patent, that a suitable agreement would be entered into with the Society respecting license to manufacture. Subsequently the Sinclair Refining Co. obtained control of the patents and has now executed an agreement upon substantially the lines originally contemplated. The agreement provides that licensees shall manufacture the instrument in strict accordance with the Society's specifications and all subsequent revisions thereof. A copy of the agreement is on file in the office of the Secretary-Treasurer.

Under the terms of this agreement the Sinclair Refining Co. has granted to the C. J. Tagliabue Manufacturing Co. the non-exclusive right to manufacture and sell the Union Colorimeter, the Executive Committee having formally approved of such licensing.

Specifications for Materials Covered by Patents:

During the year the Executive Committee has been asked to pass upon the development by Committee B-2 on Non-Ferrous Metals and Alloys of specifications for certain alloys which are either patented or in which certain processes of manufacture are covered by patents. The By-laws of the Society have for many years contained the following provision:

> "Reports, resolutions and recommendations pertaining to or involving the use, or proposed use, in a standard or tentative standard, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Society only with the approval of the Executive Committee."

It will be obvious that each case of this kind must be considered upon its respective merits, for it is conceivable that there may be circumstances surrounding the manufacture and use of certain products that will make it inadvisable for the Society to prepare standard specifications, whereas in other cases it may be entirely appropriate for such specifications to be formulated, to the decided advantage of the user of such products.

In the particular case in question the Executive Committee has decided that Committee B-2 is justified in proceeding with the development of specifications for the alloy in question, namely, aluminum bronze castings, and specifications for this alloy are being proposed.

After obtaining competent legal advice the Executive Committee has voted that the following note shall be published in connection with specifications of the Society that may cover patented materials:

> "By the adoption of this specification, the Society does not undertake to insure any one utilizing such specification against liability for infringement of any patent or assume any such liability, and such adoption does not constitute

a recommendation of any patented or proprietary application that may be involved."

During the year consideration will be given to the formulation of a statement of policy, possibly amplifying the basic provisions of the By-laws; and in consultation with Committee E-5 on Standing Committees, determining whether it is desirable to include such a statement of policy as a part of the Regulations Governing Standing Committees.

American Engineering Standards Committee:

Past-President A. A. Stevenson has been re-appointed as the Society's representative on the American Engineering Standards Committee for a term of three years. Past-Presidents J. A. Capp and F. M. Farmer are the other representatives on this committee, Mr. Farmer having been appointed to fill the unexpired term of Past-President C. D. Young, who resigned as our representative at the last annual meeting. Mr. Capp also represents the Society on the Executive Committee of the A.E.S.C.

The Executive Committee has voted to follow the policy, in submitting the Society's standards to the A.E.S.C. for approval, of requesting that the Society be designated as sponsor for such standards and future revisions thereof and of offering the personnel of the committees, or in certain cases sub-committees, of the Society responsible for such standards for approval as the sectional committee under A.E.S.C. procedure, with such additions as may be considered desirable.

The Standards Committee has adopted the following procedure in connection with revisions of standards that have received A.E.S.C. approval, which it is believed will materially facilitate the correlation of our standardization activities with A.E.S.C. procedure:

1. The sponsor for the standard is free to initiate any revision thereof, if, in so doing, the sponsor gives notice to the A.E.S.C. setting forth in such notice the reasons for and the scope of the proposed revisions, and the personnel, including the names of the other cooperating bodies represented, and the business affiliations of the committee or group in charge of the revisions.

2. Upon receipt of such notice the A.E.S.C. shall appoint a special committee to review the said scope and personnel and in the event that the special committee does not find the personnel as submitted to be a properly constituted sectional committee, it shall make definite recommendations to the A.E.S.C. for the proper execution of the work in either of the following ways:

(*a*) Through such additional direct representation of other interested organizations on the committee organized by the sponsor as will give the committee proper sectional committee status.

(*b*) Through suitable arrangements made by the sponsor to obtain the formal approval, by the other interested organizations, of the proposed revisions.

Sectional Committee on Zinc Coatings.—On October 9, 1925, the Society organized the Sectional Committee on Specifications for Zinc Coating of Iron and Steel, for which it is the sponsor.

The committee consists of about 50 officially appointed representatives from something over 30 organizations of national scope, including Government departments, interested in the development of specifications for zinc coatings. The complete personnel of the committee will be published in the Year Book of the Society. The A.S.T.M. representatives on the committee are J. A. Aupperle, J. A. Capp, J. L. Jones and H. E. Smith. At its organization meeting the committee elected as its officers, J. A. Capp, chairman; C. S. Trewin, vice-chairman; S. S. Tuthill, secretary. Its work is divided among several technical committees dealing respectively with the subjects: Hardware and Fastenings; Sheets and Sheet Products; Plates, Bars. Structural Shapes and Their Products; Pipes, Conduits and Their Fittings; Wire and Wire Products; Marine Hardware and Ship Fittings; and Methods of Testing. Six of these seven committees have organized and begun work upon the problems assigned to them. The activities of our Committee A-5 on Corrosion of Iron and Steel are being coordinated with those of the Sectional Committee.

Sectional Committee on Cast-Iron Pipe.—On April 21–22, 1926, the Sectional Committee on Specifications for Cast-Iron Pipe was organized by the four bodies that are sponsors for this committee, namely, the American Gas Association, American Water Works Association, New England Water Works Association and the A.S.T.M.

The committee consists of 32 officially appointed representatives from 11 national societies and organizations interested in the development of specifications for cast-iron pipe and 8 companies manufacturing pipe. The complete personnel of the committee will be published in the Year Book of the Society. The A.S.T.M. representatives on the committee are S. R. Church and Richard Moldenke, with a third representative still to be appointed. At its organization meeting the committee elected as its officers Thomas H. Wiggin, chairman; N. F. S. Russell, vice-chairman; C. C. Simpson, Jr., secretary. Three technical committees are being formed to handle the various phases of the work, as follows: Dimensions; Metallurgy, Processes and Tests; and Corrosion and Protective Coatings.

Sectional Committee on Copper Wire.—Committee B-1 on Copper Wire has during the year been organized as a Sectional Committee on Specifications for Hard-Drawn and Medium-Hard-Drawn Copper Wire, by the addition of formally appointed representatives from several national organizations interested in these specifications. The committee is now considering revisions of the Society's specifications covering these products.

Other sectional committees than the three above named for which the Society is now sponsor or joint sponsor are those on Zinc and Zinc Ores, Insulated Wires and Cables for Other than Telephone and Telegraph Use, Methods of Testing Wood, Standards for Drain Tile, Numbering of Steels and Fire Tests of Materials and Construction. Reports of such meetings of these committees as have been held during the year have been received and considered by the Executive Committee. The Sectional Committee on Methods of Testing Wood has advised that it wishes to continue as tentative the Methods of Testing Small Clear Specimens of Timber (D 143 – 24 T) and Methods of Conducting Static Tests of Timber in Structural Sizes (D 198 – 24 T) for at least another year before asking for their advancement to standard and approval by the A.E.S.C. The Sectional Committee on Drain Tile, the personnel of which is coincident with the Society's Committee C-6 on that subject, recommended approval of the revised Drain Tile Specifications by the A.E.S.C. as American Standard and the specifications were so approved on December 14, 1925.

The Sectional Committee on Fire Tests of Materials and Construction has presented a report to its sponsor bodies, which are the U. S. Bureau of Standards, the A.E.S.C. Fire Protection Group and the A.S.T.M., embodying Tentative Specifications for Fire Tests of Building Construction and Materials. These specifications are being presented to the Society for acceptance as tentative by Committee C-5 on Fireproofing, to which committee they were referred by the Executive Committee for consideration and report. These specifications are a revision of the present A.S.T.M. Standard Specifications for Fire Tests of Materials and Construction (C 19 – 18).

The Society has accepted an invitation of the A.E.S.C. to sponsor jointly with the A.E.S.C. Fire Protection Group the formation of a Sectional Committee on Rubber-Lined Fire Hose, and invitations have been extended to a number of organizations to appoint representatives upon such a committee. The activities of our Committee D-11 on Rubber Products will be coordinated with the work of this sectional committee.

Substantial progress is being made in the organization of Sectional Committees on Specifications for Cement and on Methods of Test of Petroleum Products and Lubricants, for both of which the Society is sponsor. The Society has also been designated sponsor for the development of Methods of Test of Road Materials and will organize Committee D-4 on Road and Paving Materials as the Sectional Committee on this subject, making such additions to the membership as may be found necessary to make the committee completely representative of all interests concerned.

In connection with the activities of the Sectional Committee on Shafting, upon which the Society is represented by F. M. Waring and J. J. Shuman, Committee A-1 on Steel will propose this year a rearrangement of the Society's specifications for screw stock and commercial bar steels so as to include certain requirements for shafting in cold-finished material, with the permissible variations therefor taken from standards prepared by the Sectional Committee and subsequently approved by the A.E.S.C. L. H. Fry has been appointed to succeed H. P. Tiemann as one of the Society's representatives on the Sectional Committee on Standardization of Gears, the other representative being T. D. Lynch. In the work of this Sectional Committee emphasis has recently been placed on specifications for materials, and the Society may become more active in its work than it has been in the past. The Society through its representative on the Sectional Committee on Special Trackwork Materials, E. F. Kenney, with the Assistant Secretary, R. E. Hess, as alternate, has followed the work of this Sectional Committee closely and taken an active part in matters relating to specifications for materials. In connection with the activities of the Sectional Committee on Pipe Flanges and Fittings, upon which the Society is represented by R. A. Bull and V. T. Malcolm, Committee A-1 has prepared for submission to the Society this year two tentative specifications in addition to the two offered a year ago. The new specifications cover forged and rolled steel pipe flanges and lap-welded and seamless steel pipe for high-temperature service.

During the year there has been organized the Sectional Committee on Scientific and Engineering Symbols and Abbreviations, upon which the Society is represented by the Assistant Secretary. The subjects before the Sectional Committee have been divided among some seven sub-committees, in only one of which the Society is particularly interested, namely, that dealing with symbols and abbreviations in the field of structural engineering and testing materials. The subcommittee on this subject was recently organized at a meeting in Columbus, Ohio, and the Society will take an active part in its work, Mr. Hess having been asked to serve as secretary of the sub-committee.

Division of Engineering, National Research Council:

Through its representatives the Society has continued to maintain contacts with the Division of Engineering and Industrial Research and its various committees, especially the Advisory Board on Highway Research, the Bureau of Welding and the Committee on Corrosion. The Society is now represented on this Division by President W. H. Fulweiler and Vice-President H. F. Moore.

U. S. National Committee of the International Electrotechnical Commission:

The Society has again taken an active part this past year in one phase of the work of the U. S. National Committee of the International Electrotechnical Commission, upon which it is represented by E. A. Snyder, namely, in the subject of insulating oils. Mr. Snyder was appointed as an official American delegate on the subject of insulating oils to the meeting of the International Electrotechnical Commission held in New York April 13–22. With the aid of a committee of advisers, among them many members of the Society's Committees on Petroleum Products and Lubricants and Electrical Insulating Materials, there was prepared a set of recommendations regarding insulating oils for use in transformers, switches, etc.

President Fulweiler formally represented the Society as one of the hosts to the visiting delegates of the International Electrotechnical Commission. He was also honored by appointment as chairman of the Advisory Committee of the International Commission on Insulating Oils and in that capacity presented the recommendations of the Advisory Committee at the Plenary Session of the Commission.

Mr. Snyder is preparing a report of the proceedings of special interest to the Society, which will be reviewed by the Executive Committee and referred to the appropriate standing committees.

Miscellaneous Joint Committees:

The Society is cooperating with the American Society for Steel Treating and the Society of Automotive Engineers in the work of a Joint Committee on Definitions of Terms Relating to Heat Treatment. The Society's representatives on the Joint Committee are H. M. Boylston and J. H. Hall, the officers of Committee A-4 on Heat Treatment of Iron and Steel, and G. B. Waterhouse, chairman of the Sub-Committee on Nomenclature and Definitions of that committee.

The Society has accepted an invitation to appoint representatives on a Joint Committee on Boiler Feed Water, functioning under the auspices of the American Water Works Association, American Society of Mechanical Engineers, American Railway Engineering Association and the National Electric Light Association. It has under consideration also the formation of an A.S.T.M. Committee on Water, for the purpose of studying certain important problems that are involved in the use of water as an engineering material.

Other Cooperative Work:

Among other cooperative work that has taken place this year should be mentioned the following: The Joint Concrete Culvert Pipe Committee has presented a report to its sponsor societies embodying

Tentative Specifications for Reinforced Concrete Culvert Pipe. Upon the recommendation of the Society's representatives on the Joint Committee consideration of this report by the Executive Committee has been deferred. The Society has been cooperating with the American Marine Standards Committee on several standardization projects, the more important being Specifications for Admiralty Condenser Tubes and Ferrule Stock, through Committee B-2 on Non-Ferrous Metals and Alloys, and Specifications for Marine Boiler Plate, through Committee A-1 on Steel. The Society has also been cooperating with the American Electric Railway Engineering Association on Specifications for Girder Rails, as will be reported this year by Committee A-1.

Cooperative work with the American Society of Mechanical Engineers through the Joint Research Committee on Effect of Temperature upon the Properties of Metals has been continued this year, the Joint Committee making very satisfactory progress. The activities of this committee come under the direction of Committee E-9 on Correlation of Research.

The Society has maintained its contacts with the work of the A.S.M.E. Boiler Code Committee through the special joint committee that considers matters relating to materials specifications.

Through Committee D-7 on Timber the Society has been cooperating with the American Railway Engineering Association in the development of Specifications and Grading Rules for Structural Timber. This cooperative work is fully covered in the annual report of that committee.

Translation of Standards:

During the past year the Department of Commerce has revised the Spanish translation of A.S.T.M. specifications to bring them in line with the specifications as printed in the 1924 Book of Standards. Copies of the following revised specifications have been received: Carbon Steel Rails (A 1 – 24), Manufacture of Open-hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 – 24), Low-Carbon-Steel Splice Bars (A 3 – 24), Structural Steel for Bridges (A 7 – 24), Structural Steel for Buildings (A 9 – 24), Quenched Carbon-Steel Track Bolts (A 50 – 24) and Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (A 83 – 24).

Respectfully submitted on behalf of the Executive Committee,

W. H. FULWEILER,
President.

C. L. WARWICK,
Secretary-Treasurer.

REPORT OF COMMITTEE A-1
ON
STEEL

During the past year Committee A-1 has held two meetings, one on January 15, 1926, and the second on March 19, 1926. A third meeting will be held prior to the presentation of this report to the Society, at which the report will be reviewed and other matters considered.

The Advisory Committee has held three meetings, at which matters concerning the general administrative affairs of the committee were considered.

The present membership of the committee is 168, of which 88 are classed as non-producers and 80 as producers.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS

The recommendations of the committee affecting standards and tentative standards are presented first in summarized form together with an analysis of the letter ballot on each item. They are then referred to, where necessary, in greater detail, being grouped for convenience in the order of the respective sub-committees directly responsible for them.

I. Proposed Revisions in Standards.—The committee recommends that the revisions in the following standards, which are given in full in the Appendix to this report, be published as tentative for one year before referring them to letter ballot of the Society for adoption as standard:

For Carbon-Steel Rails (A 1 – 24);

For the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 – 24);

For Steel Track Spikes (A 65 – 24);

For Carbon-Steel Bars for Railway Springs (A 14 – 16);

For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 – 18);

For Carbon-Steel Bars for Vehicle and Automobile Springs (A 58 – 16);

For Silico-Manganese-Steel Bars for Automobile and Railway Springs (A 59 – 16);

For Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (A 60 – 16);

For Welded and Seamless Steel Pipe (A 53 – 24);

For Boiler and Firebox Steel for Stationary Service (A 70 – 24);

For Elliptical Steel Springs for Automobiles (A 69 – 18).—The committee recommends that these specifications be withdrawn from the Book of Standards. This recommendation is made as a result of a conference with representatives of the Society of Automotive Engineers, at which time it was brought out that practically each spring customer has his own requirements for testing springs and that it is very doubtful whether a detailed standard test such as is covered by our specifications A 69 – 18 would be used. It was agreed that it would be better to withdraw these specifications.

II. Tentative Standards.—The committee recommends that the revisions in the following tentative specifications, which are given in full in the Appendix to this report, be approved, and that the specifications as thus revised be continued as tentative for another year:

For Steel Tie Plates (A 67 – 20 T);

For Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 25 T).

The committee recommends that the revisions in the following tentative specifications, which are given in full in the Appendix to this report, be approved, and that the specifications as thus revised be advanced from tentative to standard:

For Carbon Tool Steel (A 71 – 24 T);

For High-Speed Tool Steel (A 92 – 24 T);

For Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 25 T).

The committee recommends that the following tentative specifications be continued as tentative for another year:

For Low-Carbon Steel Track Bolts (A 76 – 20 T);

For Electric Cast-Steel Anchor Chain (A 77 – 20 T);

For Steel Plates of Structural Quality for Forge Welding (A 78 – 23 T);

For Steel Plates of Flange Quality for Forge Welding (A 89 – 23 T);

For Cold-Drawn Steel Wire for Concrete Reinforcement (A 82 – 21 T);

For Carbon-Steel Castings for Railroads (A 87 – 22 T);
For Carbon-Steel Car and Tender Axles (A 21 – 25 T);
For Structural Silicon Steel (A 94 – 25 T).

III. Proposed New Tentative Standards.—The committee recommends that the following new specifications, which are appended to this report,[1] be accepted for publication as tentative:

For Forged or Rolled Steel Pipe Flanges for High-Temperature Service;
For Lap-Welded and Seamless Steel Pipe for High-Temperature Service;
For Commercial-Quality Hot-Rolled Bar Steels;
For Commercial Cold-Finished Bar Steels and Cold-Finished Shafting;
For Cold-Rolled Strip Steel.

The above recommendations have been referred to letter ballot of the committee, which consists of 168 members: 153 ballots have been cast, 15 members having refrained from voting. The analysis of the vote of the committee is given in the following table:

Items	Affirmative	Negative	Not Voting[a]
I. PROPOSED REVISIONS IN STANDARDS			
1. For Carbon-Steel Rails (A 1 – 24)	63	2	88
2. For the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 – 24)	64	0	89
3. For Steel Track Spikes (A 65 – 24)	65	1	87
4. For Carbon-Steel Bars for Railway Springs (A 14 – 16)	73	0	80
5. For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements (A 68 – 18)	74	0	79
6. For Carbon-Steel Bars for Vehicle and Automobile Springs (A 58 – 16)	67	0	86
7. For Silico-Manganese-Steel Bars for Automobile and Railway Springs (A 59 – 16)	74	0	79
8. For Chrome-Vanadium-Steel Bars for Automobile and Railway Springs (A 60 – 16)	72	0	81
9. For Elliptical Steel Springs for Automobiles (A 69 – 18)	56	0	97
10. For Welded and Seamless Steel Pipe (A 53 – 24)	79	1	73
11. For Boiler and Firebox Steel for Stationary Service (A 70 – 24)	75	1	77
II. PROPOSED REVISIONS IN TENTATIVE STANDARDS			
12. For Steel Tie Plates (A 67 – 20 T)	70	0	83
13. For Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 25 T)	84	3	66
III. TENTATIVE SPECIFICATIONS ADVANCED TO STANDARD			
14. For Carbon Tool Steel (A 71 – 24 T) as revised	80	2	71
15. For High-Speed Tool Steel (A 92 – 24 T) as revised	78	2	73
16. For Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 25 T) as revised	77	3	73
IV. PROPOSED NEW TENTATIVE STANDARDS			
17. For Commercial-Quality Hot-Rolled Bar Steels	86	1	66
18. For Commercial Cold-Finished Bar Steels and Cold-Finished Shafting	81	1	71
19. For Cold-Rolled Strip Steel	67	3	83
20. For Forged or Rolled Steel Pipe Flanges for High-Temperature Service	68	4	81
21. For Lap-Welded and Seamless Steel Pipe for High-Temperature Service	59	7	87

[a] In this column are recorded the number of votes cast as "Not Voting" on the various items.

Total number of ballots cast	153
Number of Members who failed to vote	15
Total membership	168

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[1] See pp. 642–663.—ED.

The committee formally voted the following resolutions in memory of the late Mr. J. R. Onderdonk, Engineer of Tests, Baltimore & Ohio Railroad, and also a resolution of regret on the resignation of Mr. C. D. Young from membership in the committee:

RESOLVED, That Committee A-1 learned with sincere regret of the death of Mr. J. R. Onderdonk, and desires to express sympathy with his family in their loss.

Elected member of the Society in 1912, Mr. Onderdonk was appointed a member of Committee A-1 in the same year and served actively on Sub-Committees dealing with Forgings, Springs and Steel Castings. From 1922 to 1924 he was a member of the Executive Committee of the Society.

RESOLVED, That Committee A-1 accept with regret the resignation of Mr. C. D. Young, and express appreciation of the services he has rendered to the Committee. Appointed a member in 1911, Mr. Young was elected Second Vice-Chairman in 1912, the Committee report of that year making it of record "That the Committee had been strengthened on the administrative and executive side by the appointment of Mr. C. D. Young as Second Vice-Chairman." From 1914 to 1918 Mr. Young was Chairman, and as such took an active part in the preparation of the various Steel Forging Specifications. His firmness and energy contributed much to the successful completion of these important specifications which have remained in force for twelve years without substantial change. In 1922 Mr. Young was elected President of the Society.

In the following the committee presents the foregoing recommendations in detail where necessary, as well as other features of its work, grouped for convenience in the order of the respective sub-committees responsible for them.

SUB-COMMITTEE I ON RAILS AND ACCESSORIES

This sub-committee has been actively engaged in cooperation with the American Railway Engineering Association and the American Electric Railway Engineering Association committees in the harmonizing of their specifications for rails, track spikes and tie plates, and the modifications agreed upon are presented herewith.

SUB-COMMITTEE IV ON SPRING STEEL AND STEEL SPRINGS

Sub-Committee IV has cooperated with the Society of Automotive Engineers Committee and, because of the situation existing, in that the Society of Automotive Engineers has established certain standards for automobiles, it was agreed that the A.S.T.M. might well drop reference to automobile springs from the specifications under its control. This action has been taken without prejudice to any further activity in the field of automobile materials that it may later be decided to consider as subjects for specifications.

SUB-COMMITTEE IX ON STEEL TUBING AND PIPE

This sub-committee is recommending certain changes in the Specifications for Welded and Seamless Steel Pipe (A 53 – 24), for the reason that it has been found that the specifications as they now stand do not fully meet the requirements for pipe for flanging or close coiling. It was found that in the manufacture of pipe for such purposes, certain requirements were in use that were more rigid than Specifications A 53 – 24, and the proposed revisions are intended to secure material more suitable for flanging.

SUB-COMMITTEE XI ON BOILER STEELS

This sub-committee, as a result of cooperation with the Boiler Code Committee of the American Society of Mechanical Engineers, is recommending a change in the Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 24) by the addition of a new clause covering bend tests for universal edge rolled plates when permitted for double butt-strap construction.

SUB-COMMITTEE XIV ON TOOL STEEL

Sub-Committee XIV is recommending that the Specifications for Carbon Tool Steel (A 71 – 24 T) and for High-Speed Tool Steel (A 92 – 24 T) be advanced to standard, as they have met with but slight criticism which has been covered by the modifications given in this report. This action carries with it the publication as information of the Recommended Practices for Heat Treatment of the American Society for Steel Treating which are now published as appendices to the specifications.

SUB-COMMITTEE XV ON COMMERCIAL BAR STEELS

This sub-committee submits two new tentative specifications: namely, for Commercial-Quality Hot-Rolled Bar Steels and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting. These are recommended for the purpose of supplanting the present Specifications for Cold-Finished Automatic Screw Stock (Specifications A 32 – 24 and Specifications A 54 – 24) and the Specifications for Commercial Bar Steels (A 80 – 24). This action was taken because of some criticism that our present specifications were misleading in that they did not make it clear whether or not cold-finished material covered shafting. It was therefore decided to divide the specifications on the basis of the process of manufacture (hot-rolling or cold-finishing) and to include certain requirements for shafting in the cold-finished material with the permissible variations for shafting taken from the standards approved by the American Engineering Standards Committee.

SUB-COMMITTEE XIX ON SHEET STEELS

This sub-committee is presenting new Tentative Specifications for Cold-Rolled Strip Steel which it has had under consideration for a number of years, and which have necessitated a great deal of work in the harmonizing of ideas among the manufacturers and consumers of this product. These specifications are a new departure and it is felt that they will serve a very useful purpose for all parties concerned in the use of cold-rolled strip steel.

SUB-COMMITTEE XXII ON PIPE FLANGES AND FITTINGS

This sub-committee has been actively engaged in the preparation of specifications for materials for high temperature service, and is submitting new Tentative Specifications for Forged and Rolled Steel Pipe Flanges, and for Lap-Welded and Seamless-Steel Pipe for High-Temperature Service. Certain minor revisions have also been made in the Tentative Specifications for Alloy-Steel Bolting Material for High-Temperature Service (A 96 – 25 T) and in the Tentative Specifications for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service (A 95 – 25 T). Specifications A 96 – 25 T are being recommended for advancement to standard.

This report has been submitted to letter ballot of the committee, which consists of 168 members, of whom 116 have voted affirmatively, none negatively, and 52 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. WARING,
Chairman.

G. H. WOODROFFE,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Carbon-Steel Bars for Railway Springs; for Carbon-Steel Bars for Railway Springs with Special Silicon Requirements; for Carbon-Steel Bars for Vehicle and Automobile Springs; for Silico-Manganese-Steel Bars for Automobile and Railway Springs; for Chrome-Vanadium-Steel Bars for Automobile and Railway Springs; for Elliptical Steel Springs for Automobiles; for Welded and Seamless Steel Pipe; and for Boiler and Firebox Steel for Stationary Service were accepted for publication as tentative and appear on pages 1103 to 1106 and 1108 to 1110. The proposed revisions of the Standard Specifications for Carbon-Steel Rails; for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types; and for Soft Steel Track Spikes submitted as new tentative specifications to replace the present specifications were accepted for publication as tentative and appear on pages 621, 626, and 631, respectively.

The proposed revisions of the Tentative Specifications for Steel Tie Plates; and for Carbon-Steel Castings for Valves, Flanges and Fittings for High-Temperature Service were accepted. The tentative specifications as thus revised appear on pages 633 and 637, respectively.

The Tentative Specifications for Carbon Tool Steel; for High-Speed Tool Steel; and for Alloy-Steel Bolting Material for High-Temperature Service, amended as recommended in the report, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed Tentative Specifications for Commercial-Quality Hot-Rolled Bar Steels and for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting were accepted for publication as tentative to supersede, when adopted, the present Standard Specifications for Cold-Finished Bessemer Steel Automatic Screw Stock; for Cold-Finished Open-Hearth Steel Automatic Screw Stock; and for Commercial Bar Steels. The specifications appear on pages 652 and 656, respectively.

The proposed Tentative Specifications for Cold-Rolled Strip Steel; for Forged or Rolled Steel Pipe Flanges for High-Temperature Service; and for Lap-Welded and Seamless Steel Pipe for High-Temperature Service were accepted for publication as tentative and appear on pages 660, 642 and 646, respectively.

APPENDIX

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL

In this appendix are given proposed revisions in certain standard and tentative specifications, which, for convenience, are numbered from 1 to 16, inclusive, to correspond to the report of the committee. In connection with each title is given the reference to the publication in which the specifications appear in their present form.

PROPOSED REVISIONS IN STANDARDS

No. 1.—Standard Specifications for Carbon-Steel Rails: A 1 - 24.[1]

These specifications have been extensively revised and are appended hereto[2] in their revised form.

No. 2.—Standard Specifications for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types: A 2 - 24.[1]

These specifications have been extensively revised and are appended hereto[3] in their revised form.

No. 3.—Standard Specifications for Steel Track Spikes: A 65 - 24.[1]

These specifications have been extensively revised and are appended hereto[4] in their revised form.

No. 4.—Standard Specifications for Carbon-Steel Bars for Railway Springs: A 14 - 16.[1]

Section 6.—Change from its present form: namely,

> "The permissible variations in the width and thickness of the bars shall be agreed upon by the manufacturer and the purchaser."

to read as follows:

"*Permissible Variations.*—The permissible variations in width and thickness of the bars shall be:

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[1] 1924 Book of A.S.T.M. Standards.

[2] See p. 621.—Ed.

[3] See p. 626.—Ed.

[4] See p. 631.—Ed.

FLATS

	VARIATIONS IN WIDTH, IN.		VARIATIONS IN THICKNESS, IN,			
			Up to ⅜ in., Inclusive		Over ⅜ to ⅝ in., Inclusive	
	Over	Under	Over	Under	Over	Under
1 to 2 in., incl.	0.030	0.015	0.015	0.005	0.015	0.010
Over 2 to 4 in., incl.	0.047	0.015	0.015	0.005	0.015	0.010
Over 4 to 6 in., incl.	0.062	0.032	0.015	0.005	0.015	0.010

ROUNDS AND SQUARES

	VARIATIONS IN DIAMETER OR THICKNESS, IN.	
	Over	Under
Up to ½ in., incl.	0.007	0.007
Over ½ to 1 in., incl.	0.010	0.010
Over 1 to 2 in., incl.	0.016	0.016

NO. 5.—STANDARD SPECIFICATIONS FOR CARBON-STEEL BARS FOR RAILWAY SPRINGS WITH SPECIAL SILICON REQUIREMENTS: A 68 – 18.[1]

Section 6.—Make the same change as in Section 6 of Specifications A 14 – 16 above.

NO. 6.—STANDARD SPECIFICATIONS FOR CARBON-STEEL BARS FOR VEHICLE AND AUTOMOBILE SPRINGS: A 58 – 16.[1]

Title.—Change to read as follows:

"Carbon Steel Bars for Vehicle and General Purpose Springs."

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"These specifications cover two grades of carbon-steel bars to be used for the manufacture of vehicle and [automobile] *general purpose* springs, determined by the carbon ranges specified in Section 3. The choice of the grade of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and services for which it is intended. [The purpose for which these grades are frequently used are as follows:

Grade A, for vehicle springs;
Grade B, for automobile springs.]

NO. 7.—STANDARD SPECIFICATIONS FOR SILICO-MANGANESE-STEEL BARS FOR AUTOMOBILE AND RAILWAY SPRINGS: A 59 – 16.[1]

Title.—Change to read as follows:

"Silico-Manganese-Steel Bars for Railway Springs."

Section 1.—Change to read as follows by the omission of the words in brackets:

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[1] 1924 Book of A.S.T.M. Standards.

"These specifications cover [two types of] silico-manganese-steel bars to be used for the manufacture of [automobile and] railway springs, [determined by the chemical composition specified in Section 3. The choice of the type of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended.]"

Section 3.—Change from its present form: namely,

"The steel shall conform to the following requirements as to chemical composition:

ELEMENTS CONSIDERED		TYPE A	TYPE B
Carbon, per cent		0.45 - 0.55	0.55 - 0.65
Manganese, per cent		0.60 - 0.80	0.50 - 0.70
Phosphorus, max., per cent	Acid	0.05	0.05
	Basic	0.045	0.045
Sulfur, max., per cent		0.045	0.045
Silicon, per cent		1.80 - 2.10	1.50 - 1.80"

to read as follows:

"The steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.55 - 0.65
Manganese, per cent	0.60 - 0.90
Silicon, per cent	1.80 - 2.20
Phosphorus, per cent	not over 0.045
Sulfur, per cent	not over 0.045"

Section 6.—Make the same change as in Section 6 of Specifications A 14 - 16 above.

NO. 8.—STANDARD SPECIFICATIONS FOR CHROME-VANADIUM-STEEL BARS FOR AUTOMOBILE AND RAILWAY SPRINGS: A 60 - 16.[1]

Title.—Change to read as follows:

"Standard Specifications for Chrome-Vanadium-Steel Bars for Railway Springs."

Section 1.—Change to read as follows by the omission of the words in brackets:

"These specifications cover [two grades of] chrome-vanadium-steel bars to be used for the manufacture of [automobile and] railway springs, [determined by the chemical composition specified in Section 3. The choice of the grade of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended.]"

Section 3.—Change from its present form: namely,

"The steel shall conform to the following requirements as to chemical composition:

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[1] 1924 Book of A.S.T.M. Standards.

ELEMENTS CONSIDERED		GRADE A	GRADE B
Carbon, per cent		0.45 – 0.55	0.55 – 0.65
Manganese, per cent		0.50 – 0.80	0.60 – 0.90
Phosphorus, max., per cent	Acid	0.05	0.05
	Basic	0.04	0.04
Sulfur, max., per cent		0.05	0.05
Chromium, per cent		0.80 – 1.10	0.80 – 1.10
Vanadium, min., per cent		0.15	0.15"

to read as follows:

"The steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.50 – 0.60
Manganese, per cent	0.60 – 0.90
Chromium, per cent	0.90 – 1.10
Phosphorus, per cent	not over 0.045
Sulfur, per cent	not over 0.045
Vanadium, per cent	notunder 0.15"

Section 6.—Make the same change as in Section 6 of Specifications A 14 – 16 above.

NO. 9.—STANDARD SPECIFICATIONS FOR ELLIPTICAL STEEL SPRINGS FOR AUTOMOBILES: A 69 – 18.[1]

It is recommended that these specifications be withdrawn from the Book of Standards.

NO. 10.—STANDARD SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE: A 53 – 24.[1]

Section 1.—Change from its present form: namely,

"These specifications cover 'standard weight,' 'extra strong' and 'double extra strong' welded and seamless steel pipe. Pipe ordered under these specifications is intended for coiling, bending, flanging and other special purposes. Butt-welded pipe is not intended for flanging."

to read as follows:

"These specifications cover 'standard weight,' 'extra strong,' and 'double extra strong' welded and seamless steel pipe. Pipe ordered under these specifications is intended for coiling, bending, flanging and other special purposes. Butt-welded pipe is not intended for flanging. The purposes for which the pipe is intended should be stated in the order. Where seamless pipe is ordered for coiling, bending or welding, the low-carbon grade should be specified."

Section 2.—Add a new Paragraph (*c*) to read as follows:

"(*c*) Lap-welded pipe ordered for flanging shall be given a double-welding operation."

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[1] 1924 Book of A.S.T.M. Standards.

Section 3.—Change the present Section 3 to Section 3 (*a*), and add a new Paragraph (*b*) reading as follows:

"(*b*) *Check Analyses.*—Analyses may be made by the purchaser from each lot of 500 lengths or less of finished pipe. The phosphorus content thus determined shall not exceed that specified in Paragraph (*a*) by more than 25 per cent."

Section 6. (*a*).—Change from its present form: namely,

"For lap-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks."

to read as follows:

"(*a*) For lap-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks. Where welded pipe is ordered for flanging, the weld in this test shall be located 90 deg. from the line of direction of the applied force."

Insert new Paragraphs (*c*) and (*d*) to read as follows, relettering the subsequent paragraph accordingly:

"(*c*) For low-carbon seamless pipe 2 in. in diameter, a section of pipe not less than 2½ in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe, without developing cracks. In no case need the distance between plates be less than five times the thickness of the pipe."

"(*d*) For medium-carbon seamless pipe over 2 in. in diameter, a section of pipe not less than 2½ in. long shall be flattened between parallel plates until the distance between the plates is one-half the outside diameter of the pipe, without developing cracks. In no case need the distance between plates be less than seven times the thickness of the pipe."

Section 7.—Change from its present form: namely,

"For pipe 2 in. or under in diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld. This test will not be required on double extra strong pipe over 1¼ in. in diameter."

to read as follows:

"For pipe 2 in. or under in diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld. When ordered for close coiling, the pipe shall stand being bent cold through 180 deg. around a mandrel the diameter of which is eight times the diameter of the pipe, without failure. The bend test will not be required on double extra strong pipe over 1¼ in. in diameter."

Section 9.—Change from its present form: namely,

"One of each of the tests specified in Sections 4, 6 and 7, may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test."

to read as follows:

"One of each of the tests specified in Sections 4, 6 and 7 may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test. In the case of welded pipe ordered for flanging, the crop ends cut from each length shall withstand the flattening test specified in Section 6 (*a*)."

Section 10.—Change from its present form: namely,

"If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 and 7, retests of two additional pipes shall be made, each of which shall conform to the requirements specified."

to read as follows:

"If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 and 7, retests of two additional pipes shall be made, each of which shall conform to the requirements specified. In the case of flattening tests on the crop ends of each length of welded pipe, if any section fails, other pieces from the length may be cut until satisfactory tests are obtained, otherwise the length shall be rejected."

NO. 11.—STANDARD SPECIFICATIONS FOR BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE: A 70 - 24.[1]

Section 8.—Change the present Section 8 to Section 8 (*a*), and add a new Paragraph (*b*) to read as follows:

"(*b*) *Bend Test for Universal Edge Rolled Plates When Permitted for Double-Butt-Strap Construction.*—The bend test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to 1½ times the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen."

PROPOSED REVISIONS IN TENTATIVE STANDARDS

NO. 12.—TENTATIVE SPECIFICATIONS FOR STEEL TIE PLATES: A 67 - 20 T.[2]

These specifications have been extensively revised and are appended hereto[3] in their proposed revised form.

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 20, Part I, p. 493 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 15.

[3] See p. 633.—ED.

NO. 13.—TENTATIVE SPECIFICATIONS FOR CARBON TOOL STEEL: A 71 - 24 T.[1]

Section 3.—Change from its present form: namely,

> "The material shall be furnished unannealed unless otherwise specified."

to read as follows:

> "The steel shall be furnished unannealed unless otherwise specified."

Section 13.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "Material which does not conform to the chemical composition and specified [dimensional variations] *dimensions* or which at any time shows injurious defects inherent in the steel, will be rejected and the vendor shall be notified."

Appendix.—The present Tentative Recommended Practice in the Heat Treatment of Plain Carbon Tool Steel should be superseded by the present A.S.S.T. Standard Recommended Practice.

NO. 14.—TENTATIVE SPECIFICATIONS FOR HIGH-SPEED TOOL STEEL: A 92 - 24 T.[2]

Section 1. (b).—Change to read as follows by the omission of the word in brackets:

> "These [tool] steels are suitable for lathe and planer tools, milling cutters, drills, etc."

Section 2.—Change to read as follows by the omission of the word in brackets:

> "The [tool] steel shall be made either by the crucible or electric-furnace process."

Section 13.—Make the same change as in Section 13 of Specifications A 71 - 24 T above.

Appendix.—The present Tentative Recommended Practice in the Heat Treatment of 18-Per-Cent Tungsten High-Speed Steel should be superseded by the present A.S.S.T. Standard Recommended Practice.

NO. 15.—TENTATIVE SPECIFICATIONS FOR CARBON-STEEL CASTINGS FOR VALVES, FLANGES AND FITTINGS FOR HIGH-TEMPERATURE SERVICE: A 95 - 25 T.[3]

Section 1.—Change from its present form: namely,

> "These specifications cover carbon-steel castings for valves, flanges and fittings for service up to 750° F. (400° C.) total temperature."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 765 (1924): also 1925 Book of A.S.T.M. Tentative Standards, p. 19.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 771 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 25.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 519 (1925); also 1925 Book of A.S.T.M Tentative Standards, p. 63.

to read as follows:

"These specifications cover carbon-steel castings for valves, flanges and fittings for high-temperature service (Note 1)."

Add a note to read as follows:

"NOTE 1.—This contemplates temperatures up to 750° F. (400° C.); or at the discretion of the designing engineer higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the sponsorship of the Heating and Piping Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry and the American Society of Mechanical Engineers, and organized under the procedure of the American Engineering Standards Committee."

NO. 16.—TENTATIVE SPECIFICATIONS FOR ALLOY-STEEL BOLTING MATERIAL FOR HIGH-TEMPERATURE SERVICE: A 96 – 25 T.[1]

Section 1. (*a*).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"These specifications cover alloy-steel bolting material for valves, flanges and fittings [for temperatures from 400 to 750° F. (205 to 400° C.), inclusive] *for high-temperature service.* (*Note 1*). The term 'bolting material' as used in these specifications covers rolled, forged or cold-drawn bars, and bolts, screws and studs."

Add a note to read the same as Note 1 given for Tentative Specifications A 95 – 25 T above.

Section 10 (*a*).—Change from its present form: namely,

"The bolting material, after final heat treatment, shall conform to the following requirements as to tensile properties:

	CLASS A	CLASS B	CLASS C
Tensile strength, lb. per sq. in....	95 000 – 115 000	105 000 – 125 000	not less than 125 000
Yield point, min., lb. per sq. in...	70 000	80 000	105 000
Elongation in 2 in., min., per cent.	20	20	16
Reduction of area, min., per cent.	50	50	50"

to read as follows:

"10. (*a*) The bolting material, after final heat treatment, shall conform to the following requirements as to minimum tensile properties:

	CLASS A	CLASS B	CLASS C
Tensile strength, lb. per sq. in............	95 000	105 000	125 000
Yield point, lb. per sq. in................	70 000	80 000	105 000
Elongation in 2 in., per cent..............	20	20	16
Reduction of area, per cent...............	50	50	50"

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 523 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 67.

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EFFECT OF SULFUR ON RIVET STEEL: CONCLUSIONS

REPORT OF THE JOINT COMMITTEE ON INVESTIGATION OF THE EFFECT OF PHOSPHORUS AND SULFUR IN STEEL

Three preliminary reports of the Joint Committee on Investigation of the Effect of Phosphorus and Sulfur in Steel have related to the investigation of the effect of sulfur on rivet steel. The First Report[1] of the Joint Committee was presented to the meeting of the American Society for Testing Materials in 1922 and dealt with the manufacture, test methods and data relating to rivet steel containing varying amounts of sulfur from 0.03 up to 0.18 per cent. The Third Report,[2] presented in 1924, dealt with the effect of sulfur on endurance properties of rivet steel and the Fourth Report,[3] also in 1924, with a metallographic study of this material; and the committee also has before it data relating to gas content of this steel, more particularly oxygen content.

Publication of the conclusions drawn by the Joint Committee from this investigation of rivet steel has been deferred until all data on this subject were in hand. It so happens that the study of several of the series of steels with higher carbon contents is well along towards completion, such that a background is given for strengthening or confirming the conclusions on rivet steel.

It should be emphasized, however, that these conclusions may properly be considered valid only for the type of rivet steel used in this investigation, namely, a steel with a carbon range of 0.09 to 0.15 per cent, manganese 0.35 to 0.64 per cent, phosphorus 0.005 to 0.024 per cent, silicon 0.002 to 0.057 per cent, and sulfur ranging from 0.03 to 0.18 per cent.

All of the ingots and billets rolled satisfactorily, including the ingot from heat *M* (sulfur, 0.18 per cent), with the exception of the ingot from heat *P* (sulfur, 0.063 per cent) which cracked slightly in blooming.

Rivet bars and slabs were rolled from ingots that had gone cold, and directly from hot ingots; and the hot or cold ingot heats cannot be identified from the properties determined.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 94 (1922).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 96 (1924).

[3] *Ibid.*, p. 108.

The sulfur present in commercial rivet steel up to at least 0.06 per cent is not detrimental, the tests showing no systematic relation between any of the physical properties determined and the sulfur content up to 0.06 per cent.

For the following properties determined for material in the natural, annealed and quenched conditions, no systematic relation with sulfur up to 0.18 per cent is shown by these tests: Tensile strength, proportional limit and yield point for material tested both parallel and perpendicular to direction of rolling; percentages of elongation and reduction of area for material tested parallel to direction of rolling; shearing strength; hardness; torsional properties; endurance limit; cold bend tests of bars; cold bending, hot flattening and hot and cold upsetting tests of rivets.

Above sulfur of about 0.06 per cent, the values of the following properties decrease with increase in sulfur content: Percentages of elongation and reduction of area for material tested perpendicular to direction of rolling, in the three conditions, natural, annealed and quenched; Charpy and Izod impact tests for all three conditions of the material, tested parallel and perpendicular to the direction of rolling.[1]

The strength of riveted joints tested both in single shear and double shear decreases for increase in sulfur content of rivets above about 0.08 per cent.

Plotting certain of the physical properties determined from rivet bars, namely, tensile strength, proportional limit, elongation, reduction of area, shearing strength and Charpy impact, against sulfur content gives a series of curves shown in Fig. 1. In plotting these curves a base line was first established, which represented the average value of the particular property being plotted for all heats in a given condition. The difference between that average and the actual value of that property for each heat was then plotted above or below the base line depending upon whether the difference was positive or negative. Finally the curves thus determined for the three conditions were superimposed by making the base lines coincident. These curves show considerable irregularities which are, however, readily seen to be dependent mainly on the manganese and carbon contents.

It may be of interest to point out that the data of this investigation of the effect of sulfur on the properties of rivet steel have brought out important results in matters not directly concerned with the main

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[1] Determinations of the gas content of this steel show an increase in the oxygen content with an increase in sulfur above 0.06 per cent. Hydrogen and nitrogen contents, which were also determined, were found to be small and constant throughout the series of steels.

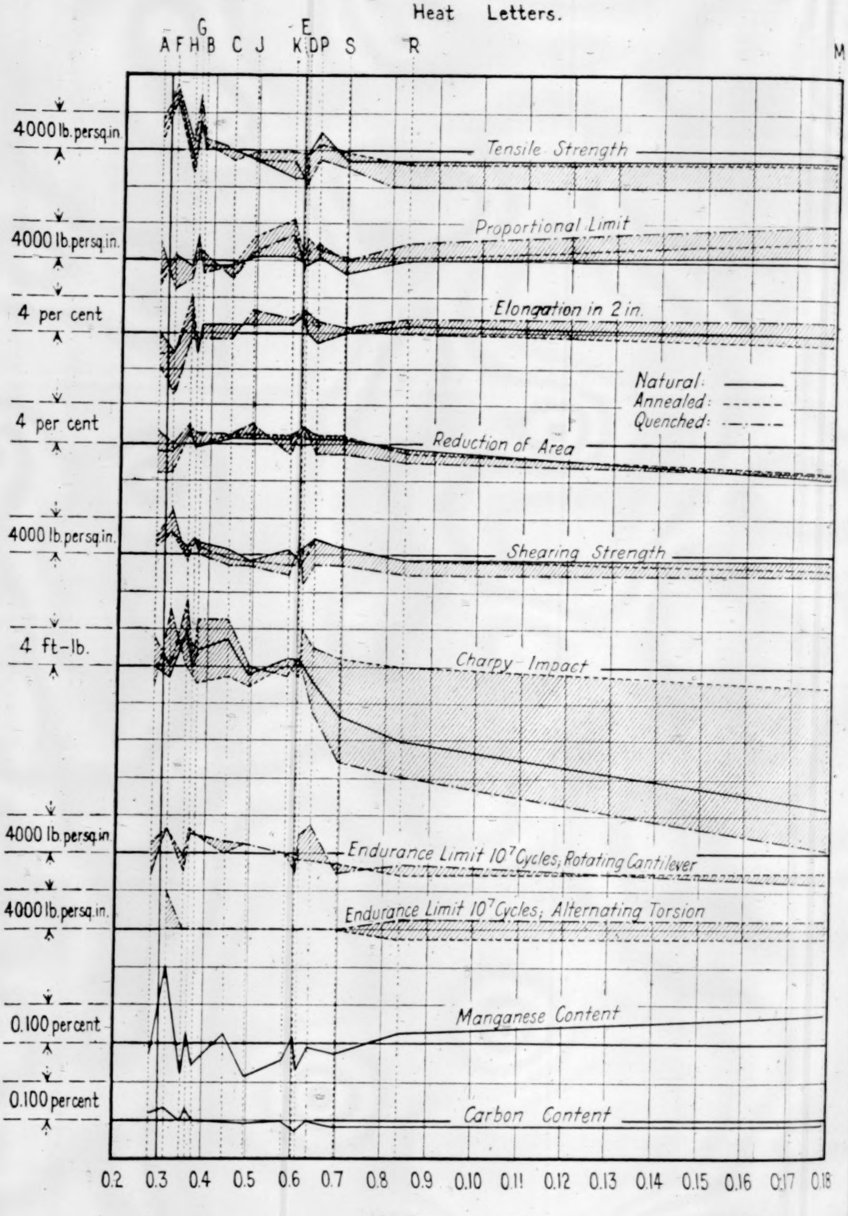

FIG. 1.—Summary Curves for Rivet Material, Group I, Phosphorus and Sulfur Investigation.

NOTE.—Rivets from all heats passed the flattening and hot and cold upsetting tests.

question, such as the effect of heat treatment and mechanical work on the properties of this type of steel, and have stimulated the study of gases in steel as well as its metallography.

In conclusion, attention should be called to the remarkable agreement in physical properties found in the total of over 5400 measurements of the various physical properties carried out independently in the two laboratories that made the tests, Watertown Arsenal and the U. S. Naval Engineering Experiment Station. Finally, it is expected that the whole report containing all data in tabular form will be published by the U. S. Bureau of Standards.

Respectfully submitted on behalf of the Joint Committee,

GEORGE K. BURGESS,
Chairman.

C. L. WARWICK,
Secretary.

REPORT OF COMMITTEE A-2
ON
WROUGHT IRON

During the year Committee A-2 has held two meetings; one at Cleveland, Ohio, and the other at Providence, R. I. Both meetings were well attended.

Sub-Committee I on Tubes and Pipe has given careful consideration to the use of wrought-iron pipe for high-temperature service. Committee A-2 believes that wrought-iron pipe conforming to the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 24) should be entirely satisfactory for such service since iron has a higher melting point than steel and any except pronounced changes in the composition would probably not have any effect upon raising the melting point of the iron. However, the committee is giving further consideration as to the temperatures to be used. Further, it believes that all iron pipe used for high temperatures should be lap welded. The thought has been expressed that possibly in some of the chemical industries wrought-iron pipe would probably show less corrosion than steel.

Sub-Committee II on Merchant Bar Iron recommends that the title of the Standard Specifications for Merchant Bar Iron (A 85 – 24)[1] be changed from its present form to read as follows:

> "Standard Specifications for *Common Iron Bars*."

Merchant bar iron is mostly a mixture of various kinds of scrap including a large percentage of steel. There has been much confusion as to just what was intended by "merchant bar iron." Many consumers would order best grades of merchant bar iron and later find that the iron failed in service and that it contained steel, with the result that all classes of iron bars were held in disrepute. With the change of title recommended many consumers will undoubtedly order the double-refined, or iron of a still better grade, as the title "common iron bars" at once indicates that such material may be unsatisfactory for general railway use.

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[1] 1924 Book of A.S.T.M. Standards.

TABLE I.—RESULTS FROM STAYBOLT IRON INVESTIGATION.

Annealing consisted in heating the specimens to 1100° F., holding at this temperature for one hour and allowing to cool slowly in air.

Serial	Condition	Diameter, in.	Physical Properties					Chemical Analysis				
			Yield Point, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Elongation in 8 in., per cent	Reduction of Area, per cent	Vibratory Test	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent
No. 1A	Natural	1	30 620	47 840	33.0	53.5	5 340	0.04	0.06	0.074	0.013	0.10
No. 1A	Annealed	1	31 080	48 060	34.0	53.7	9 050	0.04	0.06	0.074	0.013	0.10
No. 1B	Natural	1	30 160	46 310	31.0	52.6	5 080	0.04	0.08	0.064	0.012	0.10
No. 1B	Annealed	1	29 170	46 100	31.0	53.9	7 870	0.04	0.08	0.064	0.012	0.10
No. 1C	Natural	1	31 480	47 790	31.0	51.3	6 080	0.05	0.06	0.066	0.012	0.11
No. 1C	Annealed	1	31 640	47 740	30.0	51.7	6 580	0.05	0.06	0.066	0.012	0.11
No. 1D	Natural	1	32 560	47 930	32.0	51.9	5 850	0.06	0.07	0.060	0.011	0.11
No. 1D	Annealed	1	32 020	48 260	33.0	52.2	8 900	0.06	0.07	0.060	0.011	0.11
No. 1E	Natural	1	31 280	47 890	33.5	52.4	5 100	0.04	0.06	0.068	0.010	0.13
No. 1E	Annealed	1	31 230	48 230	31.0	52.9	9 350	0.04	0.06	0.068	0.010	0.13
No. 1F	Natural	1	31 320	48 390	32.0	53.3	7 380	0.06	0.07	0.063	0.010	0.11
No. 1F	Annealed	1	32 300	48 000	31.0	52.8	8 860	0.06	0.07	0.063	0.010	0.11
No. 2A	Natural	1	37 020	49 690	31.0	52.7	3 720	0.05	0.04	0.122	0.013	0.13
No. 2A	Annealed	1	32 570	49 910	30.0	51.5	7 130	0.05	0.04	0.122	0.013	0.13
No. 2B	Natural	1	35 650	48 010	31.0	53.4	6 010	0.05	0.04	0.116	0.014	0.15
No. 2B	Annealed	1	33 830	49 590	29.0	50.3	10 650	0.05	0.04	0.116	0.014	0.15
No. 2C	Natural	1	34 360	48 460	33.0	52.9	7 370	0.06	0.04	0.114	0.013	0.12
No. 2C	Annealed	1	33 050	49 270	32.0	51.9	11 300	0.06	0.04	0.114	0.013	0.12
No. 2D	Natural	1	33 580	49 420	31.0	51.1	10 330	0.05	0.04	0.116	0.013	0.13
No. 2D	Annealed	1	32 140	49 010	32.0	52.0	6 000	0.05	0.04	0.116	0.013	0.13
No. 2E	Natural	1	33 380	49 340	31.0	52.5	5 950	0.05	0.04	0.125	0.015	0.11
No. 2E	Annealed	1	33 140	48 500	30.0	52.7	7 080	0.05	0.04	0.125	0.015	0.11
No. 2F	Natural	1	32 980	47 910	30.0	51.8	9 030	0.04	0.03	0.119	0.010	0.12
No. 2F	Annealed	1	31 910	49 200	29.0	52.2	6 590	0.04	0.03	0.119	0.010	0.12
No. 3A	Natural	1	33 970	49 900	30.5	54.5	4 570	0.05	0.04	0.123	0.011	0.15
No. 3A	Annealed	1	32 860	49 010	29.0	51.2	9 750	0.05	0.04	0.123	0.011	0.15
No. 3B	Natural	1	35 650	49 980	29.0	49.2	6 840	0.06	0.04	0.121	0.010	0.16
No. 3B	Annealed	1	34 020	50 330	29.0	51.4	7 140	0.06	0.04	0.121	0.010	0.16
No. 3C	Natural	1	33 790	48 330	32.0	53.8	4 470	0.04	0.04	0.126	0.009	0.16
No. 3C	Annealed	1	32 800	49 220	31.5	53.4	15 550	0.04	0.04	0.126	0.009	0.16
No. 3D	Natural	1	34 670	49 370	32.0	52.2	6 220	0.06	0.04	0.126	0.013	0.16
No. 3D	Annealed	1	32 120	49 810	31.0	50.3	12 440	0.06	0.04	0.126	0.013	0.16
No. 3E	Natural	1	35 620	49 370	31.0	53.0	5 560	0.06	0.03	0.115	0.011	0.15
No. 3E	Annealed	1	33 790	50 100	31.0	51.1	11 920	0.06	0.03	0.115	0.011	0.15
No. 3F	Natural	1	34 300	48 660	34.0	52.1	6 750	0.06	0.04	0.122	0.011	0.16
No. 3F	Annealed	1	33 160	49 240	30.0	53.3	15 530	0.06	0.04	0.122	0.011	0.16
No. 4A	Natural	1	33 980	49 620	34.0	55.9	6 300	0.10	0.03	0.085	0.012	0.11
No. 4A	Annealed	1	30 730	48 470	34.0	55.8	10 750	0.10	0.03	0.085	0.012	0.11
No. 4B	Natural	1	33 010	48 070	34.0	56.0	7 800	0.08	0.03	0.089	0.013	0.10
No. 4B	Annealed	1	31 010	47 840	32.0	57.7	12 970[a]	0.08	0.03	0.089	0.013	0.10
No. 4C	Natural	1	32 490	48 010	33.0	56.0	6 350	0.07	0.04	0.084	0.012	0.11
No. 4C	Annealed	1	31 900	47 540	35.0	56.5	12 910[a]	0.07	0.04	0.084	0.012	0.11
No. 4D	Natural	1	31 440	46 110	35.0	60.2	10 260	0.04	0.03	0.082	0.012	0.10
No. 4D	Annealed	1	27 940	44 820	26.0[b]	54.6	9 280	0.04	0.03	0.082	0.012	0.10
No. 4E	Natural	1	32 050	48 920	35.0	56.9	6 510	0.09	0.03	0.082	0.011	0.10
No. 4E	Annealed	1	30 770	48 300	32.0	55.0	12 900	0.09	0.03	0.082	0.011	0.10
No. 4F	Natural	1	33 380	48 200	30.0	54.7	13 960	0.08	0.03	0.072	0.011	0.11
No. 4F	Annealed	1	31 540	47 390	32.0	57.2	8 790	0.08	0.03	0.072	0.011	0.11
No. 5A	Natural	1	34 030	49 080	32.0	52.9	7 020	0.04	0.04	0.118	0.010	0.15
No. 5A	Annealed	1	33 750	50 110	31.0	50.7	9 200	0.04	0.04	0.118	0.010	0.15
No. 5B	Natural	1	34 010	48 080	32.0	54.7	7 770	0.03	0.04	0.109	0.017	0.11
No. 5B	Annealed	1	33 040	49 340	32.0	53.2	9 700	0.03	0.04	0.109	0.017	0.11
No. 5C	Natural	1	33 450	47 180	34.0	52.1	6 390	0.02	0.04	0.119	0.017	0.14
No. 5C	Annealed	1	32 270	49 250	32.0	52.9	10 920	0.02	0.04	0.119	0.017	0.14
No. 5D	Natural	1	37 150	50 160	32.0	53.2	7 180	0.02	0.04	0.130	0.016	0.13
No. 5D	Annealed	1	32 760	51 320	32.0	52.0	9 800	0.02	0.04	0.130	0.016	0.13
No. 5E	Natural	1	36 090	47 960	31.0	50.8	5 930	0.04	0.04	0.111	0.016	0.14
No. 5E	Annealed	1	34 090	49 820	31.0	51.0	11 770	0.04	0.04	0.111	0.016	0.14
No. 5F	Natural	1	33 840	47 100	31.0	53.2	5 710	0.02	0.04	0.105	0.014	0.12
No. 5F	Annealed	1	32 380	48 520	31.0	52.9	10 050	0.02	0.04	0.105	0.014	0.12

[a] Grips were loose.

[b] Slivered bar.

TABLE I.—RESULTS FROM STAYBOLT IRON INVESTIGATION. (*Continued*)

Serial	Condition	Diameter, in.	Physical Properties					Chemical Analysis				
			Yield Point, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Elongation in 8 in., per cent	Reduction of Area, per cent	Vibratory Test	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent
No. 6A	Natural	15/16	33 380	46 880	30.0	52.4	10 480	0.03	0.04	0.091	0.016	0.12
No. 6A	Annealed	15/16	31 900	48 680	29.5[c]	48.8	11 750	0.03	0.04	0.091	0.016	0.12
No. 6B	Natural	15/16	34 610	46 600	30.0	49.8	6 200	0.03	0.03	0.101	0.016	0.14
No. 6B	Annealed	15/16	31 020	48 310	28.5[c]	49.9	9 530	0.03	0.03	0.101	0.016	0.14
No. 6C	Natural	15/16	34 250	46 760	32.0	55.3	20 050	0.03	0.03	0.096	0.015	0.10
No. 6C	Annealed	15/16	31 350	48 810	29.0	50.5	.....	0.03	0.03	0.096	0.015	0.10
No. 6D	Natural	15/16	35 280	46 460	27.0	47.3	8 600	0.04	0.04	0.100	0.015	0.13
No. 6D	Annealed	15/16	31 270	49 460	31.0	50.1	.....	0.04	0.04	0.100	0.015	0.13
No. 6E	Natural	15/16	35 460	47 400	27.0[c]	47.3	11 900	0.05	0.04	0.104	0.013	0.12
No. 6E	Annealed	15/16	33 580	49 090	31.0	48.3	13 430	0.05	0.04	0.104	0.013	0.12
No. 6F	Natural	15/16	33 550	46 110	29.5	54.5	10 080	0.03	0.03	0.104	0.015	0.12
No. 6F	Annealed	15/16	28 560	49 130	29.0	49.9	13 340	0.03	0.03	0.104	0.015	0.12
No. 7A	Natural	1	31 930	47 500	29.0	47.7	9 470	0.03	0.03	0.105	0.018	0.10
No. 7A	Annealed	1	29 930	48 490	31.0	48.2	8 990	0.03	0.03	0.105	0.018	0.10
No. 7B	Natural	1	33 230	48 560	30.0	48.4	5 570	0.05	0.04	0.103	0.021	0.11
No. 7B	Annealed	1	31 490	49 720	29.0	29.0	10 640	0.05	0.04	0.103	0.021	0.11
No. 7C	Natural	1	33 690	48 000	30.5	51.4	7 120	0.03	0.04	0.111	0.016	0.10
No. 7C	Annealed	1	29 240	47 930	33.0	53.3	12 870	0.03	0.04	0.111	0.016	0.10
No. 7D	Natural	1	32 320	47 940	32.0	52.5	10 080	0.03	0.04	0.104	0.018	0.11
No. 7D	Annealed	1	31 240	48 080	31.5	52.3	15 080	0.03	0.04	0.104	0.018	0.11
No. 7E	Natural	1	33 290	47 620	32.0	53.1	5 000	0.03	0.03	0.102	0.016	0.10
No. 7E	Annealed	1	33 480	48 340	32.0	54.2	10 180	0.03	0.03	0.102	0.016	0.10
No. 7F	Natural	1	34 420	46 650	33.0	50.6	6 730	0.03	0.04	0.095	0.017	0.10
No. 7F	Annealed	1	31 370	48 070	33.0	53.3	11 330	0.03	0.04	0.095	0.017	0.10
No. 8A	Natural	1 1/16	34 140	44 430	34.0	53.6	7 920	0.06	0.04	0.044	0.020	0.12
No. 8A	Annealed	1 1/16	28 970	46 650	29.0[d]	42.0	7 430	0.06	0.04	0.044	0.020	0.12
No. 8B	Natural	1 1/16	33 250	44 870	32.0[c]	52.4	5 220	0.06	0.04	0.051	0.015	0.14
No. 8B	Annealed	1 1/16	31 700	47 080	30.0	52.3	6 400	0.06	0.04	0.051	0.015	0.14
No. 8C	Natural	1 1/16	32 270	43 640	27.0	48.2	6 600	0.05	0.05	0.041	0.012	0.14
No. 8C	Annealed	1 1/16	30 330	46 560	32.0	52.4	8 500	0.05	0.05	0.041	0.012	0.14
No. 8D	Natural	1 1/16	32 410	46 810	35.0	53.0	6 550	0.03	0.06	0.118	0.019	0.15
No. 8D	Annealed	1 1/16	34 630	50 220	29.5	51.7	8 700	0.03	0.06	0.118	0.019	0.15
No. 8E	Natural	1 1/16	32 640	46 570	31.0	52.0	6 220	0.03	0.05	0.109	0.017	0.14
No. 8E	Annealed	1 1/16	32 770	49 880	30.0	51.9	7 290	0.03	0.05	0.109	0.017	0.14
No. 8F	Natural	1 1/16	35 500	49 850	28.0[c]	35.5	3 690	0.03	0.16	0.109	0.024	0.11
No. 8F	Annealed	1 1/16	34 150	52 320	30.0	44.5	4 390	0.03	0.16	0.109	0.024	0.11
No. 9A	Natural	1	34 740	50 280	31.0	50.7	5 960	0.06	0.04	0.101	0.012	0.12
No. 9A	Annealed	1	35 260	50 530	30.0	52.8	7 910	0.06	0.04	0.101	0.012	0.12
No. 9B	Natural	1	34 680	50 260	32.0	49.8	6 070	0.04	0.04	0.103	0.014	0.13
No. 9B	Annealed	1	31 200	49 710	30.0	53.3	10 370	0.04	0.04	0.103	0.014	0.13
No. 9C	Natural	1	33 570	50 320	30.0	49.8	7 750	0.06	0.04	0.085	0.011	0.12
No. 9C	Annealed	1	31 380	49 400	31.0	52.0	7 370	0.06	0.04	0.085	0.011	0.12
No. 9D	Natural	1	35 590	50 980	29.0	48.0	4 460	0.06	0.04	0.103	0.012	0.18
No. 9D	Annealed	1	35 770	50 680	30.0	50.3	9 100	0.06	0.04	0.103	0.012	0.18
No. 9E	Natural	1	35 880	50 290	28.0[b]	45.7	4 800	0.06	0.04	0.082	0.013	0.18
No. 9E	Annealed	1	32 360	49 700	27.5[b]	44.7	8 690	0.06	0.04	0.082	0.013	0.18
No. 9F	Natural	1	32 560	48 280	27.0	46.1	4 510	0.05	0.04	0.082	0.014	0.12
No. 9F	Annealed	1	33 420	48 110	29.0	49.7	7 060	0.05	0.04	0.082	0.014	0.12
No. 11A	Natural	1 1/32	33 350	48 260	33.0	54.7	7 700	0.02	0.04	0.111	0.016	0.065
No. 11A	Annealed	1 1/32	31 230	50 000	30.0	52.2	8 700	0.02	0.04	0.111	0.016	0.065
No. 11B	Natural	1 1/32	31 080	46 790	30.0	54.4	8 150	0.03	0.03	0.101	0.016	0.051
No. 11B	Annealed	1 1/32	32 950	49 430	32.0	54.7	7 640	0.03	0.03	0.101	0.016	0.051
No. 11C	Natural	1 1/32	33 820	47 180	31.0	56.6	[e]	0.03	0.04	0.108	0.017	0.051
No. 11C	Annealed	1 1/32	32 100	49 140	32.0	53.9	8 060	0.03	0.04	0.108	0.017	0.051
No. 11D	Natural	1 1/32	32 560	46 700	32.0	52.6	7 780	0.03	0.03	0.103	0.015	0.046
No. 11D	Annealed	1 1/32	32 570	49 430	29.5	53.2	7 320	0.03	0.03	0.103	0.015	0.046
No. 11E	Natural	1 1/32	32 590	47 390	33.0	54.7	8 310	0.02	0.04	0.105	0.017	0.046
No. 11E	Annealed	1 1/32	32 720	49 150	31.5	53.0	8 060	0.02	0.04	0.105	0.017	0.046
No. 11F	Natural	1 1/32	31 570	47 400	30.0	53.5	6 560	0.02	0.04	0.109	0.015	0.056
No. 11F	Annealed	1 1/32	33 420	49 850	30.0	53.7	8 090	0.02	0.04	0.109	0.015	0.056

[b] Slivered bar. [c] Fire cracks. [d] Damaged bar. [e] Bent in machine.

TABLE I.—RESULTS FROM STAYBOLT IRON INVESTIGATION. (*Continued*)

Serial	Condition	Diameter, in.	Physical Properties					Chemical Analysis				
			Yield Point, lb. per sq. in.	Tensile Strength, lb. per sq. in.	Elongation in 8 in., per cent	Reduction of Area, per cent	Vibratory Test	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent	Silicon, per cent
No. 12A	Natural	1	32 430	46 900	32.0^f	54.0	11 110	0.02	0.04	0.130	0.022	0.075
No. 12A	Annealed	1	33 110	49 500	30.5	55.1	8 860	0.02	0.04	0.130	0.022	0.075
No. 12B	Natural	1	32 350	46 870	35.0	55.8	8 512	0.03	0.04	0.113	0.021	0.056
No. 12B	Annealed	1	32 740	49 160	27.0^f	51.4	6 720	0.03	0.04	0.113	0.021	0.056
No. 12C	Natural	1	29 450	46 510	29.0^g	48.7	13 840	0.02	0.04	0.132	0.022	0.075
No. 12C	Annealed	1	30 430	48 910	25.0^h	45.9	9 220	0.02	0.04	0.132	0.022	0.075
No. 12D	Natural	1	30 460	46 050	30.0^b	50.7	9 490	0.03	0.04	0.107	0.018	0.065
No. 12D	Annealed	1	33 190	49 930	29.0	52.1	6 310	0.03	0.04	0.107	0.018	0.065
No. 12E	Natural	1	30 490	46 330	35.0	55.7	8 870	0.03	0.04	0.126	0.017	0.065
No. 12E	Annealed	1	32 840	49 410	32.0	51.5	4 810	0.03	0.04	0.126	0.017	0.065
No. 12F	Natural	1	29 160	45 920	34.0	58.0	9 010	0.03	0.04	0.123	0.017	0.094
No. 12F	Annealed	1	32 950	49 360	33.0	57.4	9 990	0.03	0.04	0.123	0.017	0.094
No. 13A	Natural	1	33 190	47 890	31.0	49.4	7 580	0.02	0.04	0.114	0.019	0.17
No. 13A	Annealed	1	32 280	48 120	31.5	49.7	6 060	0.02	0.04	0.114	0.019	0.17
No. 13B	Natural	1	30 650	46 110	33.0	49.9	11 790	0.02	0.08	0.142	0.023	0.15
No. 13B	Annealed	1	32 600	48 570	28.5^h	46.3	7 280	0.02	0.08	0.142	0.023	0.15
No. 13C	Natural	1	31 490	47 130	30.5	47.4	8 330	0.02	0.03	0.118	0.018	0.16
No. 13C	Annealed	1	31 540	47 240	29.0	46.5	5 090	0.02	0.03	0.118	0.018	0.16
No. 13D	Natural	1	33 400	47 660	29.0	49.9	8 320	0.02	0.03	0.113	0.017	0.15
No. 13D	Annealed	1	35 250	48 900	31.0	49.8	3 390	0.02	0.03	0.113	0.017	0.15
No. 13E	Natural	1	33 070	47 020	29.0	49.7	9 550	0.03	0.04	0.120	0.016	0.15
No. 13E	Annealed	1	34 460	48 640	30.0	49.3	7 340	0.03	0.04	0.120	0.016	0.15
No. 13F	Natural	1	32 350	48 260	29.0	51.3	6 940	0.03	0.05	0.119	0.019	0.10
No. 13F	Annealed	1	35 730	48 370	29.0	52.8	7 960	0.03	0.05	0.119	0.019	0.10
No. 14A	Natural	1 1/16	39 440	55 860	32.0	48.1	28 770	0.03	0.02	0.360	0.015	0.10
No. 14A	Annealed	1 1/16	40 430	57 790	31.0	49.3	6 330	0.03	0.02	0.360	0.015	0.10
No. 14B	Natural	1 1/16	32 260	50 600	32.5	55.2	6 440	0.06	0.02	0.124	0.016	0.12
No. 14B	Annealed	1 1/16	34 120	52 900	32.0	54.5	5 820	0.06	0.02	0.124	0.016	0.12
No. 14C	Natural	1 1/16	36 190	51 830	29.0	48.0	25 050	0.02	0.02	0.236	0.024	0.15
No. 14C	Annealed	1 1/16	36 830	53 520	29.0^g	48.2	8 410	0.02	0.02	0.236	0.024	0.15
No. 14D	Natural	1 1/16	32 830	49 910	29.0^b	43.7	15 760	0.09	0.04	0.206	0.019	0.16
No. 14D	Annealed	1 1/16	34 510	52 350	30.0^g	40.5	5 720	0.09	0.04	0.206	0.019	0.16
No. 14E	Natural	1 1/16	39 580	53 800	27.5^i	42.2	47 840	0.04	0.02	0.345	0.025	0.16
No. 14E	Annealed	1 1/16	38 830	55 320	30.0^g	39.7	8 410	0.04	0.02	0.345	0.025	0.16
No. 14F	Natural	1 1/16	38 090	53 810	30.0^i	44.3	24 950	0.03	0.02	0.404	0.022	0.14
No. 14F	Annealed	1 1/16	40 520	56 580	29.0^g	45.2	9 610	0.03	0.02	0.404	0.022	0.14
No. 15A	Natural	1	32 770	45 800	32.0	50.9	15 510	0.04	0.03	0.031	0.019	0.14
No. 15A	Annealed	1	33 780	46 310	32.0	52.8	4 720	0.04	0.03	0.031	0.019	0.14
No. 15B	Natural	1	29 930	45 860	32.0	54.0	11 110	0.03	0.03	0.028	0.016	0.14
No. 15B	Annealed	1	33 430	45 310	32.0	53.4	5 790	0.03	0.03	0.028	0.016	0.14
No. 15C	Natural	1	31 390	46 100	31.0	52.0	11 090	0.03	0.03	0.029	0.016	0.16
No. 15C	Annealed	1	35 000	46 280	33.0	53.8	4 730	0.03	0.03	0.029	0.016	0.16
No. 15D	Natural	1	33 450	45 350	30.0	53.0	10 590	0.03	0.03	0.032	0.019	0.16
No. 15D	Annealed	1	33 040	46 430	33.0	53.5	6 000	0.03	0.03	0.032	0.019	0.16
No. 15E	Natural	1	32 870	46 360	31.0	51.3	7 860	0.04	0.03	0.029	0.018	0.15
No. 15E	Annealed	1	32 560	46 670	31.0	54.5	5 111	0.04	0.03	0.029	0.018	0.15
No. 15F	Natural	1	32 390	46 580	30.0	51.4	9 520	0.04	0.03	0.030	0.017	0.15
No. 15F	Annealed	1	34 200	46 610	32.0	53.8	6 570	0.04	0.03	0.030	0.017	0.15

^{b} Slivered bar. ^{f} Seam in bar. ^{g} Bad weld. ^{h} Cinder. ^{i} Burnt.

It is recommended that the Standard Definitions of Terms Relating to Wrought-Iron Specifications (A 81 – 21)[1] be revised as follows:

Omit the definition for Merchant Bar Iron.

At the suggestion of Sub-Committee III on Staybolt and Engine-Bolt Iron the following revisions are recommended in the Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84 – 24):[1]

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[1] 1924 Book of A.S.T.M. Standards.

Section 2.—Change to read as follows by the addition of the italicized words:

> "Grade A.—The iron shall be rolled from a bloom, slab pile or box pile made wholly from reworked all-pig puddled iron or reworked knobbled charcoal iron. *The original puddled or knobbled bar shall be twice piled and rerolled. All bars shall be the full length of the piles.* The puddle mixture and the component parts of the bloom, slab pile or box pile shall be free from any admixture of iron scrap or steel."

Section 12.—Change the first paragraph relating to the requirements for permissible variations for the sizes of bars of Grade A material from its present form, namely,

> "*Grade A.*—The bars shall be truly round within 0.01 in., and shall not vary more than 0.01 in. above nor more than 0.005 in. below the specified size."

to read as follows:

> "*Grade A.*—The bars shall be truly round within 0.01 in. and shall be not less than 0.005 in. over, nor more than 0.020 in. over the specified diameter."

The Tentative Specifications for Hollow Staybolt Iron (A 86 – 25 T) are recommended to be continued as tentative.

Sub-Committee III has carried out some tests on staybolt iron bars before and after annealing. The chemical analyses, together with results of tension and vibratory tests, are being presented herewith in the accompanying Table I. In addition to showing the effects of annealing these tests also show the effect of phosphorus content. Other tests are under way on staybolt iron covering the range of phosphorus content. The committee is also giving consideration to the effect of annealing of staybolts after they have been threaded. The results to date indicate that staybolts will be very materially improved by annealing at 1450° F. (788° C.) after being threaded.

The committee is conducting further work with reference to the determination of slag in wrought iron as well as methods for determining the percentage of phosphorus present in the iron and slag.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
PROPOSED REVISIONS OF EXISTING STANDARDS			
Standard Specifications for Merchant Bar Iron (A 85–24)	22	0	34
Standard Definitions of Terms Relating to Wrought-Iron Specifications (A 81–21)	22	0	34
Standard Specifications for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars (A 84-24)	22	0[a]	34

This report has been submitted to letter ballot of the committee, which consists of 56 members, of whom 22 have voted affirmatively, none negatively, and 34 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. J. FORCE,
Chairman.

C. C. OSTERHOUT,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Merchant Bar Iron; for Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars; and the Standard Definitions of Terms Relating to Wrought-Iron Specifications were accepted for publication as tentative and appear on pages 1112, 1111, and 1112, respectively.

REPORT OF COMMITTEE A-5

ON

CORROSION OF IRON AND STEEL

The report of Committee A-5 shows continued activity on the part of its sub-committees, with substantial progress in all of its work during the past year.

Sub-Comittee III on Inspection of the Fort Sheridan and Annapolis Tests reports additional failures at Fort Sheridan and Annapolis, the rate of corrosion at Annapolis being considerably slower than at Fort Sheridan. At Fort Sheridan 70 per cent of the non-copper-bearing light-gage sheets have failed, while only 1.5 per cent of the copper-bearing sheets have failed. It is significant that a very large proportion of the good sheets arbitrarily classified as non-copper-bearing (below 0.15 per cent of copper) show by analysis a copper content over 0.10 per cent. At Annapolis the failures are largely confined to the light-gage low-copper open-hearth steel and low-copper pure iron; one of the copper-bearing sheets have failed.

Sub-Committee V on Total Immersion Tests have made periodic inspections of the tests at Annapolis and Washington, completing the tests on the light-gage specimens. Table IV of the report of the sub-committee gives a comparison of the failures of the light-gage sheets under three widely varying water exposures, which information shows that where the metals are submerged the presence of copper does not give increased resistance to corrosion. The sub-committee has arranged to study under salt water (open ocean water) the effect of corrosion on steel ship plate with and without copper when riveted with rivets of iron and steel with varying copper contents, these tests giving promise of valuable information to the shipping interests in establishing whether or not metals of unlike copper contents can be economically fabricated together.

Sub-Committee VI on Specifications for Metallic-Coated Products has extended its work during the past year by taking up galvanized materials other than sheets. They offer for acceptance as tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire, for Galvanized Iron or Steel Telephone and Telegraph Line Wire and for Galvanized Iron or Steel Tie Wires. These specifications when adopted will be offered to the Sectional Committee of the American Engineering Standards Committee as information. The sub-committee is studying representative samples of sherardized materials and hopes to offer specifications for such material by another year.

Sub-Committee VII on Accelerated Tests has continued its study of "short-time" corrosion tests, briefly described as "simulated atmospheric tests," wherein the samples were exposed to a warm moist atmosphere containing 1 per cent of SO_2 and 5 per cent of CO_2, combined with water spray; "intermittent alternate-immersion tests," wherein the samples were repeatedly immersed in a 2-per-cent solution of ammonium chloride at 15-minute intervals until evidence of rust of the sheet metal was obtained; and "sodium chloride spray tests," wherein the samples were subjected to a fog produced by atomizing a 20-per-cent solution of sodium chloride, removing and cleaning with a stiff bristle brush every 24 hours for examination. The work done indicates that no sweeping conclusions as to the relative merits of these tests are warranted, and while the three methods of attack vary widely in severity, the results show that the five types of coatings tested would be placed in the same general order, although the order would not be exactly the same in each case.

Sub-Committee VIII on Field Tests of Metallic-Coated Products has made substantial progress during the past year in the development of its program of atmospheric tests and reports the completion of the test racks at five locations representing as many differing conditions of atmosphere. Plans are now being worked out for collecting, testing and fabricating the wire and fencing samples, and the hardware, pipe, conduit and structural shapes will follow in a short time. The Inspection Committee whose duties it will be to inspect and report upon the tests has been organized and the first inspections will be made during the coming year. It is gratifying to report widespread interest and continued liberal support from many sources interested in determining reliable data on the relative resistance of various coatings under service conditions.

This report has been submitted to letter ballot of the committee, which consists of 77 members, of whom 44 have voted affirmatively, 1 negatively, and 32 have refrained from voting.

Respectfully submitted on behalf of the committee,

J. H. GIBBONEY,
Chairman.

JAMES ASTON,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire; for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire; and for Zinc-Coated (Galvanized) Iron or Steel Tie Wires were accepted for publication as tentative and appear on pages 664, 667 and 672, respectively.

REPORT OF SUB-COMMITTEE III ON INSPECTION OF THE FORT SHERIDAN, PITTSBURGH AND ANNAPOLIS TESTS

Sub-Committee III on Inspection has held two meetings during the past year.

FIRST MEETING

The first meeting was held at Fort Sheridan, Ill., on September 18, 1925, with Messrs. Beck, Gibboney, McDonnell, Smith, Taylerson and Captain Cassidy, representing the Quartermaster's Corps of the United States War Department, present; Messrs. Cooper, Fleming and the representative of the Bureau of Steam Engineering of the United States Navy Department being absent. The following additional failures were recorded:

Sheet AA-11 (No. 16 Gage Bessemer Steel, Series A) failed due to a 1-in. hole near the bottom of the sheet.

Sheet C-6 (No. 22 Gage Copper-Bearing Pure Iron, Series A) failed due to ragged edge at the bottom of the sheet.

Sheet E-13 (No. 22 Gage Puddled Iron, Series A) failed due to ragged edge at the lower left hand corner.

Sheet Y-5 (No. 22 Gage Low-Copper Wrought Iron, Series B), manufactured by the Youngstown Sheet and Tube Co. This sheet failed due to a hole in lower left hand corner.

Sheets A-20, 23, 26 and 28 (No. 22 Gage Bessemer Steel, Series A) failed due to small holes near the bottom of the sheets.

Sheet A-24 (No. 22 Gage Bessemer Steel, Series A) failed due to ragged edge at the bottom of the sheet.

Sheet X-22 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the Inland Steel Co. This sheet failed due to a small hole near the bottom of the sheet.

Sheet X-23 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the Inland Steel Co. This sheet failed due to small holes near the edge of the sheet.

The sheets at Annapolis, Md., were inspected on October 10, 1925, by Messrs. Beck, Gibboney, Smith, Taylerson, Thompson and Wheaton; Messrs. Cooper, Fleming and McDonnell being absent. The following additional failures were recorded:

Sheets O-3, 4, 5 and 9 (No. 22 Gage Low-Copper Open-hearth Steel, Series A) failed due to ragged edge at the bottom of the sheets.

Sheet S-4 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the American Rolling Mill Co. This sheet failed due to small holes near the bottom of the sheet.

No photographic record was made of the failed sheets at Fort Sheridan and Annapolis. The members of the sub-committee observed that very little change in the general characteristics of the sheets had taken place since the preceding inspection; however, a detailed record covering the condition of the sheets at both Fort Sheridan and Annapolis as regarding texture, color and adherence of rust was made and this data has been filed with the Secretary-Treasurer of the Society for any future reference.

SECOND MEETING

The second meeting was held at Providence, R. I., on March 18, 1926, with Messrs. Beck, Cooper, Gibboney, McDonnell, Smith and Taylerson present; Messrs, Fleming, McAdam and Wheaton being absent. At this meeting it was decided to request certain members of the sub-committee convenient to the Fort Sheridan and Annapolis tests to inspect the sheets and report the failures and general conditions to the chairman, which information would determine whether or not there had been sufficient development in the test since October, 1925, to warrant inspection by the entire sub-committee.

Messrs. McAdam and Wheaton inspected the Annapolis, Md., sheets on March 29, 1926, and report that the general appearance of the sheets has not changed materially since October, 1925. The following additional failures were recorded:

Sheet O-2 (No. 22 Gage Low-Copper Open-hearth Steel, Series A).

Sheet S-14 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co.

Mr. H. E. Smith inspected the Fort Sheridan, Ill., sheets on April 8, 1926, and reported the general appearance of the sheets about the same as in Spetember, 1925, with the following additional failures:

Sheet X-24 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co. This sheet failed due to transverse cracks near the bottom of the sheet.

Sheet X-26 (No. 22 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co. This sheet failed due to a small hole near the bottom of the sheet.

Sheet X-28 (No. 22 Gage Low-Copper Pure Iron, Series B) manufactured by the Inland Steel Co. This sheet failed due to a hole and several transverse cracks near the bottom of the sheet.

In view of the above findings no further inspection of the sheets at Annapolis and Fort Sheridan was made in the spring.

Table I, Plate I, is presented as a continuation of the same general plan of grouping all sheets at the Fort Sheridan location as regarding the presence of copper and recording the failures at all inspection periods. It will be noted that after nine years' exposure practically all of the No. 22 gage sheets in seven groups of low-copper bessemer and open-hearth steel and pure iron, 57 out of a total of 83 sheets have failed. It is significant that a very large number of the remaining good sheets arbitrarily classified as non-copper-bearing (below 0.15 per cent of copper) show by analysis a copper content over 0.10 per cent. Only two copper-bearing No. 22 gage sheets (E-13 and C-6) out of a total of 136 have failed in the nine years' exposure.

Table II, Plate II, is presented as a continuation of the same general plan of grouping all sheets at the Annapolis location as regarding the presence of copper and recording the failures at all inspection periods. It will be noted that the rate of failure at this location is considerably slower than at Fort Sheridan. However, the failures so far recorded are in the light gage and in the same groups of low-copper open-hearth steel and pure iron failing first at Pittsburgh and Fort Sheridan. None of the copper-bearing sheets in the light-gage and none of the heavy-gage non-copper-bearing or copper-bearing sheets have failed.

This report has been considered by the sub-committee and unanimously approved.

Respectfully submitted on behalf of the sub-committee,

J. H. GIBBONEY,
Chairman.

TABLE I.—FAILURES AT FORT SHERIDAN TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, 1922, 1923, 1924, 1925, AND APRIL, 192

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test				
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Mar. 31, 1919.[a] 24 Months	Dec. 6, 1919. 32 Months	May 10, 1920. 37 Months	Oct. 11 42 Mo
													No. 16 Gage Sheets	
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319	12	None	None	None	No
HH	Copper-Bearing Basic Open-hearth Steel	A	” ”	0.074	0.373	0.011	0.026	0.004	0.237	17	None	None	None	No
II	Copper-Bearing Bessemer Steel	A	” ”	0.059	0.371	0.095	0.066	0.006	0.247	19	None	None	None	No
KK	Copper-Bearing Acid Open-hearth Steel	A	” ”	0.108	0.433	0.085	0.043	0.005	0.234	19	None	None	None	No
CCC	Copper-Bearing Pure Iron	A	” ”	0.023	0.026	0.005	0.028	0.005	0.236	12	None	None	None	No
TT	Copper-Bearing Steel, Newport Rolling Mill Co.	B	” ”	0.050	0.313	0.009	0.020	0.006	0.223	14	None	None	None	No
UU	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	” ”	0.018	0.066	0.008	0.028	0.005	0.239	13	None	None	None	No
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	” ”	0.018	0.046	0.007	0.019	0.004	0.299	19	None	None	None	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ”	0.08	0.40	0.091	0.035	0.006	0.154	1	None	None	None	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ”	0.08	0.34	0.094	0.037	.....	0.279	2	None	None	None	No
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ”	0.07	0.36	0.082	0.033	.....	0.528	2	None	None	None	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ”	0.06	0.37	0.050	0.052	.....	0.172	2	None	None	None	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ”	0.09	0.34	0.038	0.077	0.003	0.641	2	None	None	None	No
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ”	0.06	0.39	0.019	0.044	.....	0.318	2	None	None	None	No
	Total			.....	.....	.....	.....	.....	.....	136	None	None	None	No
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012	17	None	None	None	No
BB	Open-hearth Steel	A	” ” ”	0.056	0.349	0.022	0.048	0.037	0.129	17	None	None	None	No
OC	Copper-Bearing Pure Iron	A	” ” ”	0.019	0.029	0.004	0.032	0.003	0.067	12	None	None	None	No
DD	Low-Copper Pure Iron	A	” ” ”	0.019	0.028	0.004	0.027	0.004	0.028	19	None	None	None	No
OO	Low-Copper Open-hearth Steel	A	” ” ”	0.108	0.371	0.009	0.029	0.007	0.029	12	None	None	None	No
MM	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	” ” ”	0.017	0.414	0.010	0.029	0.007	0.057	14	None	None	None	No
SS	Low-Copper Pure Iron, American Rolling Mill Co.	B	” ” ”	0.017	0.021	0.006	0.021	0.006	0.025	12	None	None	None	No
XX	Low-Copper Pure Iron, Inland Steel Co.	B	” ” ”	0.021	0.062	0.008	0.030	0.005	0.028	14	None	None	None	No
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	” ” ”	0.03	0.051	0.123	0.019	0.203	0.023	3	None	None	None	No
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ” ”	0.08	0.45	0.102	0.037	0.008	0.014	2	None	None	None	No
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ” ”	0.022	0.39	0.040	0.028	.....	0.030	2	None	None	None	No
	Total			.....	.....	.....	.....	.....	.....	124	None	None	None	No
													No. 22 Gage Sheets	
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.156	2	None	None	None	No
C	Copper-Bearing Pure Iron	A	” ”	0.015	0.028	0.005	0.036	0.003	0.195	10	None	None	None	No
E	Puddled Iron	A	” ”	0.033	0.034	0.114	0.021	0.134	0.283	12	None	None	None	No
H	Copper-Bearing Basic Open-hearth Steel	A	” ”	0.069	0.387	0.016	0.027	0.004	0.244	11	None	None	None	No
I	Copper-Bearing Bessemer Steel	A	” ”	0.041	0.365	0.097	0.068	0.008	0.252	19	None	None	None	No
K	Copper-Bearing Acid Open-hearth Steel	A	” ”	0.107	0.447	0.091	0.046	0.004	0.237	16	None	None	None	No
M	Open-hearth Steel, Alan Wood Iron and Steel Co.	B	” ”	0.093	0.419	0.013	0.041	0.011	0.185	14	None	None	None	No
T	Copper-Bearing Steel, Newport Rolling Mill Co.	B	” ”	0.083	0.313	0.009	0.020	0.005	0.227	14	None	None	None	No
U	Copper-Bearing Pure Iron, Allegheny Steel Co.	B	” ”	0.017	0.074	0.008	0.037	0.005	0.260	14	None	None	None	No
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co.	B	” ”	0.018	0.051	0.007	0.021	0.005	0.304	14	None	None	None	No
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ”	0.06	0.37	0.094	0.038	0.007	0.263	2	None	None	None	No
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ”	0.05	0.37	0.114	0.048	.....	0.533	2	None	None	None	No
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ”	0.06	0.35	0.049	0.059	.....	0.212	2	None	None	None	No
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ”	0.06	0.39	0.047	0.047	.....	0.286	2	None	None	None	No
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ”	0.07	0.41	0.042	0.042	.....	0.532	2	None	None	None	No
	Total			.....	.....	.....	.....	.....	.....	136	None	None	None	No
A	Bessemer Steel	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014	15	None	None	16, 17, 18 (3)	No
B	Open-hearth Steel	A	” ” ”	0.09	0.38	0.017	0.062	0.036	0.103	11	None	None	None	No
C	Copper-Bearing Pure Iron	A	” ” ”	0.01	0.028	0.002	0.027	0.002	0.144	2	None	None	None	No
D	Low-Copper Pure Iron	A	” ” ”	0.02	0.026	0.004	0.022	0.002	0.024	6	None	None	None	No
O	Low-Copper Open-hearth Steel	A	” ” ”	0.121	0.536	0.008	0.030	0.249	0.020	12	None	14, 15, 21 (3)	13, 16, 19, 23, 24 (5)	17, 18, (4
S	Low-Copper Pure Iron, American Rolling Mill Co.	B	” ” ”	0.02	0.023	0.006	0.022	0.001	0.022	14	None	None	None	No
X	Low-Copper Pure Iron, Inland Steel Co.	B	” ” ”	0.021	0.055	0.007	0.031	0.004	0.027	14	None	None	None	No
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co.	B	” ” ”	0.03	0.055	0.139	0.021	0.218	0.020	3	None	None	None	4 (
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ” ”	0.07	0.44	0.107	0.046	0.003	0.011	2	None	None	None	No
Z	Bessemer Steel, Youngstown Sheet and Tube Co.	B	” ” ”	0.06	0.38	0.077	0.035	0.009	0.130	2	None	None	None	No
Z	Open-hearth Steel, Youngstown Sheet and Tube Co.	B	” ” ”	0.06	0.32	0.065	0.044	0.002	0.018	2	None	None	421 (1)	No
	Total			.....	.....	.....	.....	.....	.....	83	None	3	9	5

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.

[a] No failures were recorded at inspections made prior to March 31, 1919; the detail records are accordingly not given here.

PLATE I.
PROC. AM. SOC. TESTING MATS.
VOL. 26, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

L, 1926. SHEETS EXPOSED APRIL 9, 1917. COMPARING COPPER-BEARING WITH NON-COPPER-BEARING MATERIALS.[1]

Date of Inspection												Number of Sheets Failed in Test
Oct. 11, 1920. 42 Months	Apr. 4, 1921. 48 Months	Oct. 17, 1921. 54 Months	Apr. 10, 1922. 60 Months	Oct. 16, 1922. 66 Months	Mar. 8, 1923. 71 Months	Oct. 12, 1923. 78 Months	Apr. 16, 1924. 84 Months	Oct. 12, 1924. 90 Months	Mar. 11, 1925. 95 Months	Sept. 18, 1925. 101 Months	Apr. 8, 1926. 108 Months	
ETS												
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	13 (1)	None	None	None	None	None	None	None	11 (1)	None	2
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	1	None	None	None	None	None	None	None	1	None	2
TS												
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	6 (1)	None	1
None	None	None	None	None	None	None	None	None	None	13 (1)	None	1
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	2	None	2
None	19, 29, 30, (3)	None	None	22 (1)	None	25 (1)	21 (1)	None	None	20, 23, 24, 26, 28 (5)	None	14
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	None	None	22 (1)	None	None	None	None	None	None	None	1
17, 18, 20, 22 (4)	....	....	....	....	....	....	....	....	....	....	....	12 (all)
None	None	16, 22, 25, 26, 28 (5)	17, 18, 19, 20, 21 23, 24, 27 (8)	15 (1)	....	....	....	....	....	....	....	14 (all)
None	25 (1)	None	None	15, 17 (2)	None	None	None	None	16 (1)	22, 23 (2)	24, 26, 28 (3)	9
4 (1)	None	None	None	None	None	6 (1)	None	None	None	5 (1)	....	3 (all)
None	4, 5 (2)	....	....	....	....	....	....	....	....	....	....	2 (all)
None	None	None	None	None	None	None	None	None	None	None	None	None
None	None	420 (1)	....	....	....	....	....	....	....	....	....	2 (all)
5	6	6	8	5	None	2	1	None	1	8	3	57

TABLE II.—FAILURES AT ANNAPOLIS TESTS. INSPECTIONS OF 1917, 1918, 1919, 1920, 1921, 1922,
COMPARING COPPER-BEARING WITH NON-COPPE

Group	Designation	Series	Description	Average analysis, per cent					
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper
							No. 16 GAGE SHEETS		
EE	Puddled Iron	A	Copper-Bearing	0.035	0.03	0.119	0.018	0.125	0.319
HH	Copper-Bearing Basic Open-hearth Steel	A	" "	0.074	0.373	0.014	0.026	0.004	0.237
II	Copper-Bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247
KK	Copper-Bearing Acid Open-hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234
CCC	Copper-Bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236
TT	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.080	0.313	0.009	0.020	0.006	0.223
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.018	0.066	0.008	0.028	0.005	0.239
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.046	0.007	0.019	0.004	0.299
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.113	0.413	0.109	0.015	.....	0.167
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.080	0.34	0.091	0.036	.....	0.293
ZZ	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.073	0.305	0.089	0.015	None	0.532
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.074	0.39	0.069	0.072	.....	0.255
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.077	0.363	0.057	0.080	0.002	0.652
ZZ	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.06	0.42	0.050	0.048	Trace	0.363
	Total	......	....	.....	.....	.....	.....	.....	.....
AA	Bessemer Steel	A	Non-Copper-Bearing	0.043	0.419	0.083	0.042	0.004	0.012
BB	Open-hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.113
CC	Copper-Bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067
DD	Low-Copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028
OO	Low-Copper Open-hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029
MM	Open-hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.017	0.414	0.010	0.029	0.007	0.057
SS	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025
XX	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028
YY	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.08	0.43	0.080	0.031	0.008	0.014
ZZ	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.047	0.389	0.040	0.027	0.007	0.033
	Total	......	....	.....	.....	.....	.....	.....	.....
							No. 22 GAGE SHEETS		
B	Open-hearth Steel	A	Copper-Bearing	0.06	0.27	0.014	0.053	0.006	0.187
C	Copper-Bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.194
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283
H	Copper-Bearing Basic Open-hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244
I	Copper-Bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252
K	Copper-Bearing Acid Open-hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237
M	Open-hearth Steel, Alan Wood Iron and Steel Co	B	" "	0.093	0.419	0.013	0.041	0.011	0.185
T	Copper-Bearing Steel, Newport Rolling Mill Co	B	" "	0.083	0.313	0.009	0.020	0.005	0.227
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.017	0.074	0.008	0.037	0.005	0.260
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.051	0.007	0.021	0.005	0.304
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.058	0.37	0.093	0.043	0.009	0.269
Z	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.055	0.38	0.110	0.046	.....	0.527
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.067	0.351	0.045	0.052	0.003	0.187
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.065	0.35	0.050	0.059	0.003	0.264
Z	Copper-Bearing Open-hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.073	0.42	0.052	0.054	Trace	0.641
	Total	......	....	.....	.....	.....	.....	.....	.....
A	**Bessemer Steel**	A	Non-Copper-Bearing	0.038	0.386	0.089	0.040	0.007	0.014
B	Open-hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.084
C	Copper-Bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.141
D	Low-Copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024
O	Low-Copper Open-hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027
Y	Low-Copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.063	0.41	0.102	0.044	0.009	0.013
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.077	0.44	0.095	0.036	0.003	0.140
Z	Open-hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.032	0.32	0.063	0.042	.....	0.019
	Total	......	....	.....	.....	.....	.....	.....	.....

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper-bearing, and those above 0.15 per cent copper as copper-bearing.

[a] No failures were recorded at inspections made prior to March 5, 1923; the detail records are accordingly not given here.

PLATE II.
PROC. AM. SOC. TESTING MATS.
VOL. 26, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

1922, 1923, 1924, 1925, and March, 1926. Sheets Exposed October 17, 1916.
opper-Bearing Materials.[1]

	Number of Sheets in Test	Date of Inspection							Number of Sheets Failed in Test
pper		Mar. 5, 1923.[a] 77 Months	Oct. 10, 1923. 84 Months	Apr. 18, 1924. 90 Months	Oct. 23, 1924. 96 Months	Mar. 27, 1925. 101 Months	Oct. 10, 1925. 108 Months	Mar. 29, 1926. 113 Months	
ets									
.319	12	None	None	None	None	None	None	None	None
.237	16	None	None	None	None	None	None	None	None
.247	16	None	None.	None	None	None	None	None	None
.234	18	None	None	None	None	None	None	None	None
.236	12	None	None	None	None	None	None	None	None
.223	14	None	None	None	None	None	None	None	None
.239	14	None	None	None	None	None	None	None	None
.299	14	None	None	None	None	None	None	None	None
.167	2	None	None	None	None	None	None	Bone	None
.293	3	None	None	None	None	None	None	None	None
.532	2	None	None	None	None	None	None	None	None
.255	3	None	None	None	None	None	None	None	None
.652	2	None	None	None	None	None	None	None	None
.363	2	None	None	None	None	None	None	None	None
....	130	None	None	None	None	None	None	None	None
.012	18	None	None	None	None	None	None	None	None
.113	17	None	None	None	None	None	None	None	None
.067	12	None	None	None	None	None	None	None	None
.028	19	None	None	None	None	None	None	None	None
.029	12	None	None	None	None	None	None	None	None
.057	14	None	None	None	None	None	None	None	None
.025	14	None	None	None	None	None	None	None	None
.028	14	None	None	None	None	None	None	None	None
.023	3	None	None	None	None	None	None	None	None
.014	3	None	None	None	None	None	None	None	None
.033	3	None	None	None	None	None	None	None	None
....	129	None	None	None	None	None	None	None	None
s									
.187	10	None	None	None	None	4 (1)	None	None	1
.194	9	None	None	None	None	None	None	None	None
.283	11	None	None	None	None	None	None	None	None
.244	16	None	None	None	None	None	None	None	None
.252	16	None	None	None	None	None	None	None	None
.237	16	None	None	None	None	None	None	None	None
.185	14	None	None	None	None	None.	None	None	None
.227	14	None	None	None	None	None	None	None	None
.260	14	None	None	None	None	None	None	None	None
.304	14	None	None	None	None	None	None	None	None
.269	3	None	None	None	None	None	None	None	None
.527	3	None	None	None	None	None	None	None	None
.187	3	None	None	None	None	None	None	None	None
.264	3	None	None	None	None	None	None	None	None
.641	3	None	None	None	None	None	None	None	None
....	149	None	None	None	None	1	None	None	1
.014	14	None	None	None	None	None	None	None	None
.084	2	None	None	None	None	None	None	None	None
.141	3	None	None	None	None	None	None	None	None
.024	7	None	None	None	None	None	None	None	None
.020	12	None	1 (1)	None	None	None	3, 4, 5, 9 (4)	2 (1)	6
.022	14	None	5 (1)	None	7 (1)	8 (1)	4 (1)	14 (1)	5
.027	14	None	None	None	None	None	None	None	None
.020	3	None	None	None	None	None	None	None	None
.013	3	None	None	None	None	None	None	None	None
.140	3	None	None	None	None	None	None	None	None
.019	3	None	None	None	None	None	None	None	None
....	78	None	2	None	1	1	5	2	11

ar.

TABLE I.—REPORT ON SUBMERGED TESTS. SHEETS

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test		
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		Oct. 18, 1922, 868 Days	April 14, 1923, 1046 Days
A	Bessemer Steel	A	Non-Copper-Bearing	0.034	0.373	0.093	0.035	0.0065	0.016	6		
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.067	0.400	0.104	0.046	0.009	0.013	6		
Z1	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.077	0.435	0.096	0.036	0.003	0.139	6		
I	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.053	0.344	0.096	0.066	0.0035	0.249	6		
Z2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	"	0.060	0.388	0.095	0.041		0.266	6		207
Z3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	"	0.051	0.366	0.112	0.052		0.541	6		
O	Basic Open-Hearth Steel	A	Non-Copper-Bearing	0.115	0.512	0.010	0.029	0.251	0.014	6		2, 5
B	Basic Open-Hearth Steel	A	" " "	0.034	0.226	0.0115	0.055	0.0045	0.144	6		
Z4	Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.077	0.351	0.068	0.055	0.004	0.185	6		417
H	Copper-Bearing Basic Open-Hearth Steel	A	Copper-Bearing	0.085	0.367	0.011	0.027	0.0025	0.252	6		
M	Copper-Bearing Basic Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" "	0.099	0.391	0.012	0.042	0.012	0.188	6		
T	Copper-Bearing Basic Open-Hearth Steel, Newport Rolling Mill Co	B	" "	0.078	0.322	0.0095	0.019	0.010	0.237	6		24
Z5	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.065	0.350	0.047	0.0535	0.003	0.189	6		501
Z6	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.060	0.320	0.046	0.064	0.003	0.263	6		
Z7	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.070	0.415	0.049	0.051	Trace	0.634	6		705
D	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.022	0.024	0.0038	0.024	0.002	0.026	6		1, 15
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	0.011	0.065	0.006	0.029	0.003	0.033	6		3, 12
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	0.011	0.015	0.006	0.022	0.007	0.022	6		2, 4
C	Copper-Bearing Pure Iron	A	Copper-Bearing	0.025	0.036	0.007	0.035	0.002	0.194	6		2, 10
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.017	0.078	0.008	0.039	0.004	0.253	6		
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.013	0.068	0.007	0.022	0.005	0.306	6		2
K	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.111	0.435	0.087	0.045	0.003	0.220	6		
Y	Low-Copper Puddled Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.053	0.149	0.021	0.220	0.020	6	1	1, 2
E	Copper-Bearing Puddled Iron	A	Copper-Bearing	0.039	0.032	0.114	0.021	0.110	0.241	6		
										144	1	18
	Total Failures to Date	...	...	...	...	...	...	...	...	...	...	19

CETS EXPOSED JUNE 2, 1920, IN RUNNING SEVERN RIVER WATER AT THE NAVAL ENGINEERING EXPERIMENT STATION, ANNAPOLIS, MD.

NO. 22 GAGE SHEET

Failures on Date of Inspections																					
1046 Days	June 8, 1923, 1101 Days	July 11, 1923, 1134 Days	Aug. 17, 1923, 1171 Days	Sept. 17, 1923, 1202 Days	Oct. 18, 1923, 1232 Days	Nov. 19, 1923, 1264 Days	Dec. 21, 1923, 1296 Days	Jan. 22, 1924, 1328 Days	March 4, 1924, 1370 Days	April 3, 1924, 1400 Days	May 5, 1924, 1432 Days	June 7, 1924, 1465 Days	July 9, 1924, 1497 Days	Aug. 8, 1924, 1527 Days	Sept. 9, 1924, 1559 Days	Oct. 9, 1924, 1589 Days	Nov. 11, 1924, 1622 Days	Dec. 13, 1924, 1654 Days	Jan. 14, 1925, 1686 Days	Feb. 28, 1925, 1721 Days	Apr. 21, 1925,
	102		1, 2 102 108	2	9 3 102		108		4, 5 108		7	4	4, 4		12						
207			204	1	3	15 204 301	301			207		301, 305	207		206 303, 305				9	12	
, 5 417	4, 7		3	413	417	9	416		413	4 416	15	16					9				
24 501 705	4 4 603	7	2, 5 9 22 602 707	503	13 2 503, 503 602	501		603		14 20 705	8, 17	707	11	707		602		11	501		
, 15 , 12 , 4	1	6	8, 10	4	9		12			8			13						5		
, 10 2			8	10		3, 11	4	13 6	5	8 5 12			6 7, 9		12						
			3						6		8		12	10, 15							
, 2		2, 3						2	4	3											
18	7	4	16	6	11	7	5	4	7	11	5	5	9	3	5	1	1	1	3	1	
19	26	30	46	52	63	70	75	79	86	97	102	107	116	119	124	125	126	127	130	131	1

—Report on Submerged Tests. Sheets Exposed June 2, 1920, in Running Severn River Water at the Naval Engineering Experime

No. 22 Gage Sheet

Analysis, per cent				Number of Sheets in Test	Failures on Date of Inspections																
Phosphorus	Sulfur	Silicon	Copper		Oct. 18, 1922, 868 Days	April 14, 1923, 1046 Days	June 8, 1923, 1101 Days	July 11, 1923, 1134 Days	Aug. 17, 1923, 1171 Days	Sept. 17, 1923, 1202 Days	Oct. 18, 1923, 1232 Days	Nov. 19, 1923, 1264 Days	Dec. 21, 1923, 1296 Days	Jan. 22, 1924, 1328 Days	March 4, 1924, 1370 Days	April 3, 1924, 1400 Days	May 5, 1924, 1432 Days	June 7, 1924, 1465 Days	July 9, 1924, 1497 Days	Aug. 8, 1924, 1527 Days	Sept. 9, 1924, 1559 Days
.093	0.035	0.0065	0.016	6						2	9				4, 5		7				12
.104	0.046	0.009	0.013	6					1, 2		3							4	4, 4		
.096	0.036	0.003	0.139	6			102		102 108		102		108		108						
.096	0.066	0.0035	0.249	6						1	3	15									
.095	0.041		0.266	6		207			204			204				207			207		206
.112	0.052		0.541	6								301	301					301, 305			303,305
.010	0.029	0.251	0.014	6		2, 5	4, 7		3			9									
.0115	0.055	0.0045	0.144	6												4	15	16			
.068	0.055	0.004	0.185	6		417				413	417		416		413	416					
.011	0.027	0.0025	0.252	6					2, 5							14	8, 17		11		
.012	0.042	0.012	0.188	6			4	7	9		13										
.0095	0.019	0.010	0.237	6		24	4		22		2					20					
.047	0.0535	0.003	0.189	6		501				503	503, 503	501									
.046	0.064	0.003	0.263	6			603		602		602			603							
.049	0.051	Trace	0.634	6		705			707							705		707		707	
.0038	0.024	0.002	0.026	6		1, 15				4									13		
.006	0.029	0.003	0.033	6		3, 12	1				9					8					
.006	0.022	0.007	0.022	6		2, 4		6	8, 10				12								
.007	0.035	0.002	0.194	6		2, 10									5	8			6		12
.008	0.039	0.004	0.253	6								3, 11		13		5			7, 9		
.007	0.022	0.005	0.306	6		2			8	10			4	6		12					
.087	0.045	0.003	0.220	6					3						6		8		12	10, 15	
.149	0.021	0.220	0.020	6	1	1, 2		2, 3								3					
.114	0.021	0.110	0.241	6										2	4						
				144	1	18	7	4	16	6	11	7	5	4	7	11	5	5	9	3	5
......	....	....	....	....	......	19	26	30	46	52	63	70	75	79	86	97	102	107	116	119	124

PLATE III.
PROC. AM. SOC. TESTING MATS.
VOL. 26, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

ERIMENT STATION, ANNAPOLIS, MD.

Sept. 9, 1924, 1559 Days	Oct. 9, 1924, 1589 Days	Nov. 11, 1924, 1622 Days	Dec. 13, 1924, 1654 Days	Jan. 14, 1925, 1686 Days	Feb. 28, 1925, 1721 Days	Apr. 21, 1925, 1783 Days	May 23, 1925, 1815 Days	July 6, 1925, 1859 Days	Aug. 6, 1925, 1890 Days	Sept. 9, 1925, 1924 Days	Nov. 21, 1925, 2000 Days	Average Life in Days.			
12												1360.8 1338.8 1223.5	1307.7	A Z Z1	1366.3 Days
206 303,305				9	12						6	1517.5 1322.8 1434.6	1424.9	I Z2 Z3	
		9						1			12	1121.5 1629.6 1257.6	1341.8	O B Z4	2 Low Copper, 1139 Days 4 High Copper, 1317 Days
	602		11	501		3 1		705			602	1350.5 1345.8 1288.8 1277.0 1403.5 1411.3	1343.2	H M T Z5 Z6 Z7	1342.8 Days
				5			17	6				1410.8 1251.8 1144	1268.9	D X S	1290.3 Days
12												1319.6 1375 1240.5	1311.7	C U V	
												1420.6	1420.6	K	1420.6 Days
						12			6		8, 10	1104.6 1728.5	1104.6 1728.5	Y E	1416.5 Days
5	1	1	1	3	1	3	1	3	1	0	5				
124	125	126	127	130	131	134	135	138	139	139	144				

TABLE II.—REPORT ON SUBMERGED TESTS. SHEETS EXPOSED AUGUST 10, 1920, IN RUNNING WA

NO. 16 GAGE SHEET

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test	Jan. 24, 1924, 1261 Days
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper		
AA	Bessemer Steel	A	Non-Copper-Bearing	0.053	0.428	0.088	0.042		0.009	6	
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.076	0.385	0.096	0.037		0.012	6	
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.055	0.381	0.099	0.066		0.236	6	
ZZ1	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.080	0.400	0.091	0.035	0.056	0.154	6	
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.088	0.306	0.089	0.046		0.271	6	
ZZ3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.066	0.363	0.085	0.033		0.548	6	
OO	Basic Open-Hearth Steel	A	Non-Copper-Bearing	0.116	0.378	0.010	0.026	0.005	0.030	6	3
MM	Basic Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.101	0.426	0.009	0.032		0.048	6	
ZZ4	Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.029	0.395	0.044	0.026		0.029	6	
BB	Basic Open-Hearth Steel	A	" " "	0.043	0.316	0.033	0.062	0.097	0.126	6	
HH	Copper-Bearing Basic Open-Hearth Steel	A	Copper-Bearing	0.085	0.391	0.013	0.025		0.230	6	
TT	Copper-Bearing Basic Open-Hearth Steel, Newport Rolling Mill Co	B	" "	0.078	0.301	0.008	0.021		0.215	6	
ZZ5	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.065	0.367	0.053	0.064		0.223	6	
ZZ6	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.090	0.330	0.034	0.055		0.574	6	
ZZ7	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.063	0.391	0.052	0.045		0.355	6	
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.021	0.033	0.004	0.031		0.060	6	
DD	Low-Copper Pure Iron	A	" " "	0.021	0.029	0.004	0.025		0.025	6	
SS	Pure Iron, American Rolling Mill Co	B	" " "	0.014	0.018	0.006	0.024		0.027	6	
XX	Pure Iron, Inland Steel Co	B	" " "	0.026	0.054	0.008	0.026		0.029	6	
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.016	0.026	0.005	0.026	0.005	0.220	6	
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.016	0.065	0.009	0.030		0.244	6	
VV	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.017	0.039	0.007	0.021		0.290	6	
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.118	0.408	0.081	0.043		0.229	6	
YY	Low-Copper Puddled Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.060	0.124	0.018	0.216	0.024	6	
EE	Copper-Bearing Puddled Iron	A	Copper-Bearing	0.033	0.045	0.117	0.017	0.132	0.325	6	
										150	
	Total Failures to Date	....	....	....	....	....	....	....	....	....	.....

PLATE IV.
PROC. AM. SOC. TESTING MATS.
VOL. 26, PART I.
REPORT OF COMMITTEE A-5:
TOTAL IMMERSION TESTS.

WASHINGTON CITY WATER AT THE U. S. BUREAU OF STANDARDS, WASHINGTON, D. C.

SHEETS

Failures on Date of Inspections																
Jan. 24, 1924, 1261 Days	Aug. 14, 1924, 1464 Days	Sept. 20, 1924, 1501 Days	Nov. 20, 1924, 1562 Days	Dec. 17, 1924, 1589 Days	Jan. 14, 1925, 1624 Days	Feb. 28, 1925, 1662 Days	Mar. 27, 1925, 1689 Days	Apr. 27, 1925, 1720 Days	June 4, 1925, 1758 Days	July 7, 1925, 1791 Days	Aug. 7, 1925, 1822 Days	Sept. 8, 1925, 1854 Days	Oct. 20, 1925, 1896 Days	Nov. 20, 1925, 1927 Days	Jan. 11, 1926, 1979 Days	Feb. 13, 1926, 2012 Days
	37						40 14, 14		52					43 7		
	55 213	213			106	106 314, 314					45, 47 208		208 310	106	40, 50	106, 106 209 310
35	422		427	426	39	36	34	42	31			422		37 422	31, 33 40	33 426
				39		510 615	715		36 507	46, 48 27	40 32, 33	42	44 714			714
				11		25	36	16	57		12	53	24 42	50 34		
											33, 34, 28 37		26, 29 55	29, 30	35	
						57			52			45, 47			40	
			7			1		7	1			1		7		
								23			33				30	27
1	4	1	2	3	2	9	6	4	7	3	12	6	9	10	8	8
....	5	6	8	11	13	22	28	32	39	42	54	60	69	79	87	95

REPORT OF SUB-COMMITTEE V ON TOTAL IMMERSION TESTS

The test racks have been periodically inspected and since the last report of the sub-committee all of the No. 22 gage sheets at Annapolis have failed, and 95 sheets out of 150 sheets of the No. 16 gage sheets at the U. S. Bureau of Standards and 82 sheets out of 150 sheets of the No. 16 gage sheets at Annapolis have failed.

Table I (Plate III) gives the record of the No. 22 gage sheets at the Naval Engineering Experiment Station at Annapolis, Md., all of which have failed.

Table II (Plate IV) gives the record of the No. 16 gage sheets at the Bureau of Standards, Washington, D. C. In the first inspection of the No. 16 gage sheets at Annapolis on August 6, 1925, 60 failures were found. This is an unusual number of failures to find in one inspection, and the sub-committee believes that if an earlier inspection had been made, some of these would have been found to have failed before August 6, 1925, but the sub-committee can record only the results of the inspection, so includes in its report photographs of the failures found in August, 1925, and those interested may draw their own conclusions (Figs. 1 to 16).

Table III gives the record of the No. 16 gage sheets at the Naval Experiment Station at Annapolis, Md.

Table IV gives a comparison of the failures of the No. 22 gage sheets at Calumet Mine; Bureau of Standards, Washington, D. C.; and Annapolis, Md. This finishes the original tests of the No. 22 gage sheets.

Table V gives the average chemical analyses of the waters at Calumet Mine; Bureau of Standards, Washington, D. C.; and Annapolis, Md.

The sub-committee is installing samples of the No. 22 gage and No. 16 gage sheets at the Portsmouth, N. H., and Key West, Fla., Navy Yards in open sea waters. These installations are being made at the request of the Bureau of Construction and Repair, U. S. Navy Department.

Lloyds' Register of Shipping reports that the shipping interests are experiencing great trouble and expense from the rapid corrosion and failure of rivets in standard ship plates, and has asked the sub-committee to make some investigations. The Bureau of Construction and Repair, U. S. Navy Department, is also interested,

TABLE III.—REPORT ON SUBMERGED TESTS. SHEETS EXPOSED JUNE 2, 1920, IN RUNNING SEVERN RIVER WATER AT THE NAVAL ENGINEERING EXPERIMENT STATION, ANNAPOLIS, MD.

NO. 16 GAGE SHEETS

Group	Designation	Series	Description	Average Analysis, per cent						Number of Sheets in Test	Aug. 6, 1925, 1890 Days	Sept. 9, 1925, 1924 Days	Oct. 22, 1925, 1967 Days	Nov. 24, 1925, 2000 Days	Feb. 19, 1926, 2087 Days
				Carbon	Manganese	Phosphorus	Sulfur	Silicon	Copper						
AA	**Bessemer** Steel	A	Non-Copper-Bearing	0.036	0.428	0.084	0.042		0.011	6		1, 10			
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.080	0.427	0.081	0.031	0.008	0.014	6	4	1			2
II	Copper-Bearing Bessemer Steel	A	Copper-Bearing	0.062	0.353	0.093	0.065	0.006	0.255	6		1, 10			
ZZ1	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.112	0.412	0.109	0.045		0.167	6	103, 102, 102	102			
ZZ2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.076	0.340	0.088	0.034		0.291	6	202	201			
ZZ3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.072	0.305	0.089	0.045		0.532	6		307			
OO	Basic Open-Hearth Steel	A	Non-Copper-Bearing	0.109	0.358	0.011	0.029		0.025	6	1, 3, 4, 6	7, 8			
MM	Basic Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.110	0.420	0.008	0.027	0.010	0.063	6	2, 7, 15				5
ZZ4	Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.060	0.390	0.040	0.024		0.033	6	417, 418, 418, 418			417	
BB	Basic Open-Hearth Steel	A	" " "	0.046	0.296	0.025	0.058		0.138	6	3, 6, 9, 15				
HH	Copper-Bearing Basic Open-Hearth Steel	A	Copper-Bearing	0.083	0.369	0.011	0.026	0.002	0.252	6	2, 5, 12				
TT	Copper-Bearing Basic Open-Hearth Steel, Newport Rolling Mill Co	B	" "	0.087	0.338	0.008	0.019		0.221	6	1, 6, 8, 9				
ZZ5	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.078	0.390	0.071	0.075		0.256	6	503	501			
ZZ6	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.079	0.359	0.055	0.080		0.651	6					
ZZ7	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	0.060	0.420	0.050	0.048		0.363	6					
CC	Low-Copper Pure Iron	A	Non-Copper-Bearing	0.022	0.031	0.005	0.031	0.003	0.086	6	7	3			5
DD	Low-Copper Pure Iron	A	" " "	0.020	0.027	0.004	0.028	0.002	0.027	6	11, 15, 16	12, 13			
SS	Pure Iron, American Rolling Mill Co	B	" " "	0.022	0.032	0.005	0.018	0.007	0.027	6	3, 9, 17				
XX	Pure-Iron, Inland Steel Co	B	" " "	0.028	0.079	0.009	0.029		0.034	6	3, 5, 7, 32, 35	2			
CCC	Copper-Bearing Pure Iron	A	Copper-Bearing	0.022	0.027	0.005	0.028	0.006	0.251	6	3, 4, 12, 15				
UU	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	0.028	0.071	0.006	0.031	0.006	0.247	6	4, 6, 7, 8		1		
VV	Copper-Bearing Pure Iron, Whitaker-Glessner	B	" "	0.024	0.051	0.006	0.017		0.308	6	1, 19, 30, 31, 32				
KK	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	0.098	0.453	0.085	0.041		0.220	6	9, 12, 16	6			
YY	Low-Copper Puddled Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	0.030	0.050	0.127	0.018	0.197	0.024	6	8, 8, 8, 8	9			
EE	Copper-Bearing Puddled Iron	A	Copper-Bearing	0.045	0.026	0.114	0.019	0.117	0.300	6					
										150	60	17	1	1	3
	Total Failures to Date											77	78	79	82

TABLE IV.—TOTAL IMMERSION TESTS. COMPARISON OF FAILURES OF NO. 22 GAGE SHEETS ($\frac{1}{32}$ IN. IN THICKNESS).

Group	Designation	Series	Description	Exposed to Running Mine Water, Calumet Mine, Pittsburgh District			Exposed to Running City Water, Bureau of Standards, Washington, D. C.			Exposed to Running Severn River Water, Naval Engineering Experimental Station, Annapolis, Md.		
				Average Number of Days Before Failure			Average Number of Days Before Failure			Average Number of Days Before Failure		
A	Bessemer Steel	A	Non-Copper-Bearing	52.5	55.6	51.7	881.83	899.1	889.63	1360.8	1307.7	1366.3
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	51.33			915.66			1338.8		
Z1	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	63			899.83			1223.5		
I	Copper-Bearing Bessemer Steel	A	Copper-Bearing	35	47.83		863	880.16		1517.5	1424.9	
Z2	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	56			853.16			1322.8		
Z3	Copper-Bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	52.2			924.33			1434.6		
O	Basic Open-Hearth Steel	A	Non-Copper-Bearing	36.16	40.25	44.85	869.66	874.82	867.47	1121.5	1341.8	1342.8
B	Basic Open-Hearth Steel	A	" " "	39.66			881			1629.6		
Z4	Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	44.33			873.83			1257.6		
H	Copper-Bearing Basic Open-Hearth Steel	A	Copper-Bearing	39.66	46.16		875.83	863.8		1350.5	1343.2	
M	Copper-Bearing Basic Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" "	50.16			760.16			1345.8		
T	Copper-Bearing Basic Open-Hearth Steel, Newport Rolling Mill Co	B	" "	58.33			923.16			1288.8		
Z5	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	38.5			852.66			1277.0		
Z6	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	50.16			873.33			1403.5		
Z7	Copper-Bearing Basic Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" "	46.66			897.66			1411.3		
D	Low-Copper Pure Iron	A	Non-Copper-Bearing	51.33	47.44	46.27	804.5	899.72	933.66	1410.8	1209.3	1260.5
X	Low-Copper Pure Iron, Inland Steel Co	B	" " "	43.16			996.66			1073		
S	Low-Copper Pure Iron, American Rolling Mill Co	B	" " "	47.83			898			1144		
C	Copper-Bearing Pure Iron	A	Copper-Bearing	39.66	45.11		854.33	967.61		1319.6	1311.7	
U	Copper-Bearing Pure Iron, Allegheny Steel Co	B	" "	36.16			1047.16			1375		
V	Copper-Bearing Pure Iron, Whitaker-Glessner Co	B	" "	59.5			1001.33			1240.5		
K	Copper-Bearing Acid Open-Hearth Steel	A	Copper-Bearing	52.5	52.5	52.5	821.83	821.83	821.83	1420.6	1420.6	1420.6
Y	Low-Copper Puddled Iron, Youngstown Sheet and Tube Co	B	Non-Copper-Bearing	46.66	46.66	48.41	740.5	740.5	766	1104.6	1104.6	1416.5
E	Copper-Bearing Puddled Iron	A	Copper-Bearing	50.16	50.1		791.5	791.5		1728.5	1728.5	
	Average Number of Days, All Sheets				47.54			879.2			1337.5	
	Average Number of Days, Non-Copper-Bearing Sheets				47.59			876.1			1266.4	
	Average Number of Days, Copper-Bearing Sheets				47.47			881.4			1388.3	

and with their cooperation the sub-committee will install at Portsmouth, N. H., and Key West, Fla., Navy Yards a series of riveted test samples to determine, if possible, the effect of corrosion on plates with different analyses, when riveted with rivets of different analyses, when totally immersed in open sea waters.

TABLE V.—AVERAGE CHEMICAL ANALYSES OF WATER FROM TANKS IN WHICH NO. 22 GAGE SHEETS WERE EXPOSED.

CALUMET MINE TEST[1]	
Average Water Temperature	15.68° C.
Acidity, Parts per Million in Terms of Calcium Carbonate:	
Due to free sulfuric acid	713.3
Due to free sulfuric acid, plus sulfates of iron and aluminum	1727
Ferrous sulphate, ($FeSO_4$)	295
Ferric sulfate, $Fe_2(SO_4)_3$	917.2
Total Iron Sulfates (Ferrous Sulfate plus Ferric Sulfate)	1212.2
BUREAU OF STANDARDS TEST, WASHINGTON, D. C.[2]	
Average Water Temperature	18.05° C.
Alkalinity in Terms of Calcium Carbonate (Methyl Orange), parts per million	66.7
Dissolved Oxygen, c.c. per liter	5.1
P H (Phenol Red)	not taken
ANNAPOLIS, MD., TEST[2]	
Average Water Temperature	14.2° C.
Alkalinity in Terms of Calcium Carbonate (Methyl Orange), parts per million	59.1
Dissolved Oxygen, cc. per liter	5.01
P H (Phenol Red)	7.6
Analysis of Sample of Water Taken at 12 Noon, November 19, 1923:	
Bicarbonate (HCO_3)	85.2
Chloride (Cl)	8440
Sulfate (SO_4)	1169
Carbonate (CO_3)	none
Sodium and Potassium, Calculated as Sodium (Na)	4782
Calcium (Ca)	192
Magnesium (Mg)	567
Iron Oxide and Aluminum (Fe_2O_3 and Al_2O_3)	3.1
Silica (SiO_2)	2.3
Total Dissolved Solids Dried at 180° C	15 491

Fig. 17 shows the form of riveted test plates to be used in these tests. There will be two plates of steel each with copper 0.03 per cent or under, two plates of steel each with copper 0.25 to 0.30 per cent,

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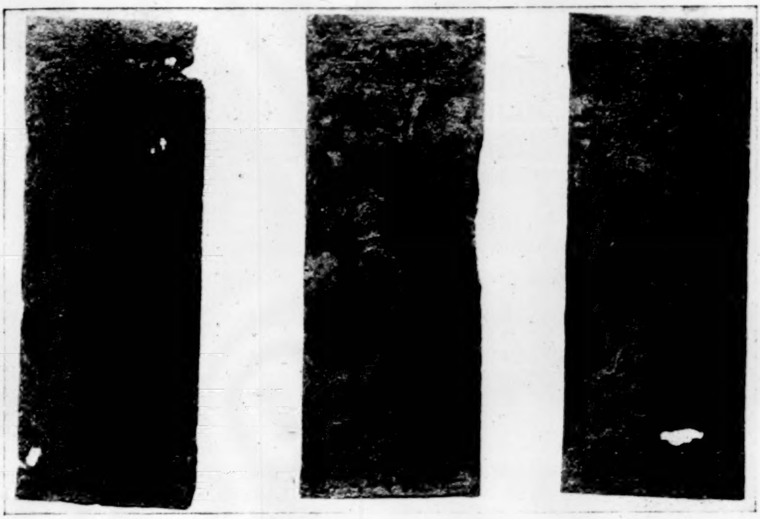
[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 157 (1921).

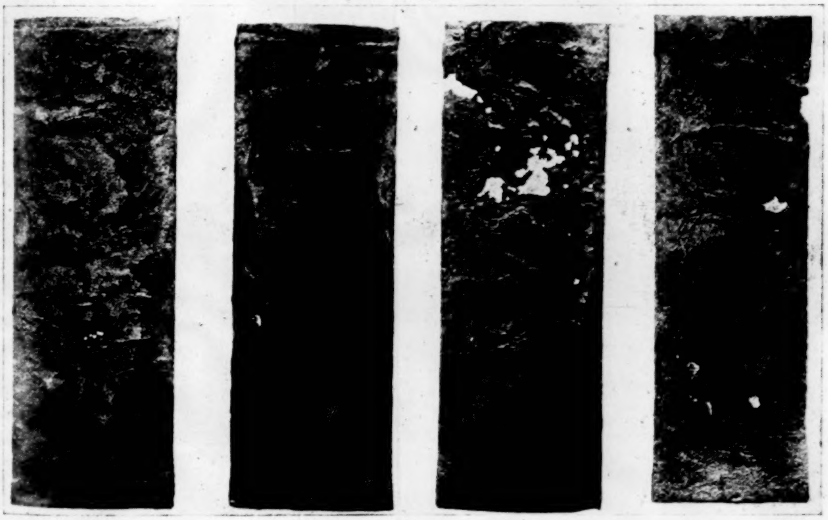
[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 226 (1924).



ZZ 102. ZZ 102. ZZ 103.

FIG. 1.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

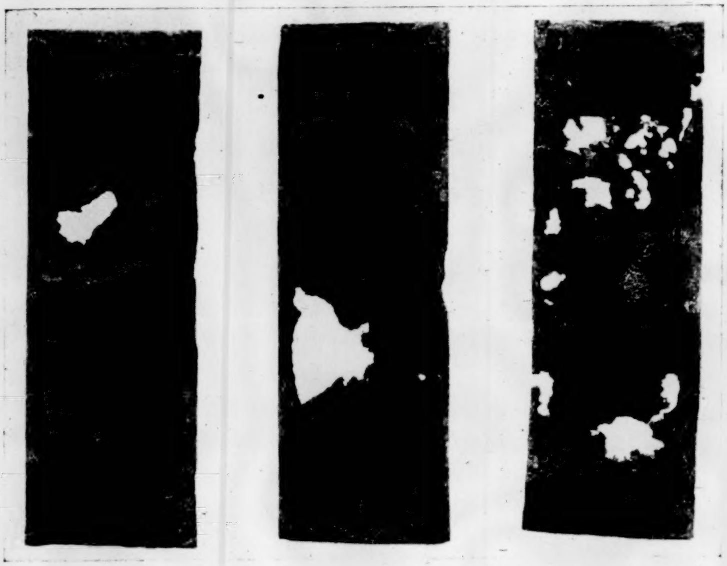
Inspection, August 6, 1925, 1890 days.



OO 6. OO 4. OO 3. OO 1.

FIG. 2.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

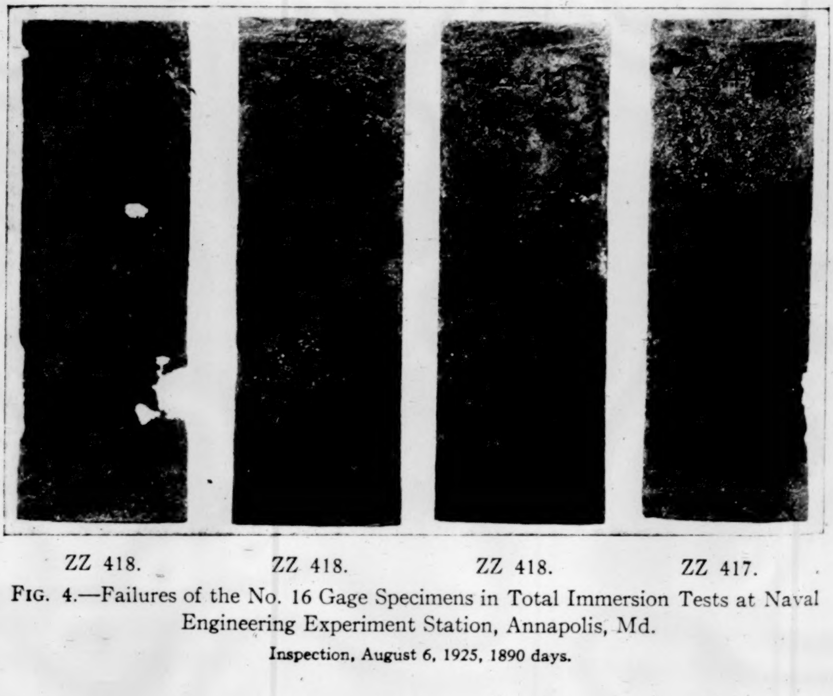
Inspection, August 6, 1925, 1890 days.



MM 15. MM 7. MM 2.

FIG. 3.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

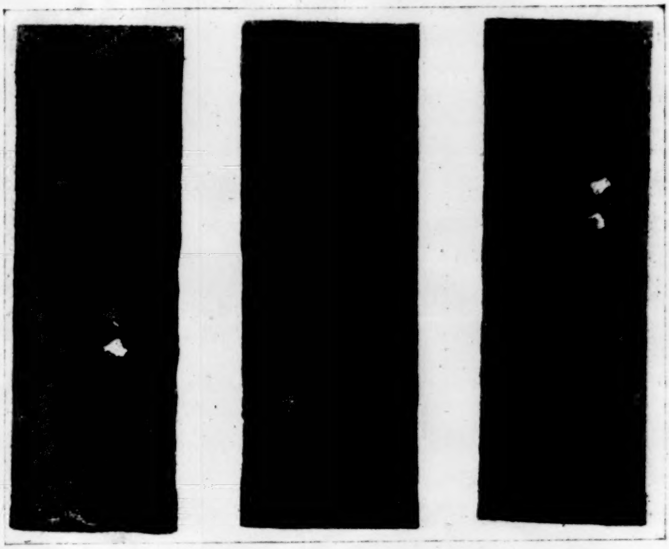
Inspection, August 6, 1925, 1890 days.



ZZ 418. ZZ 418. ZZ 418. ZZ 417.

FIG. 4.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

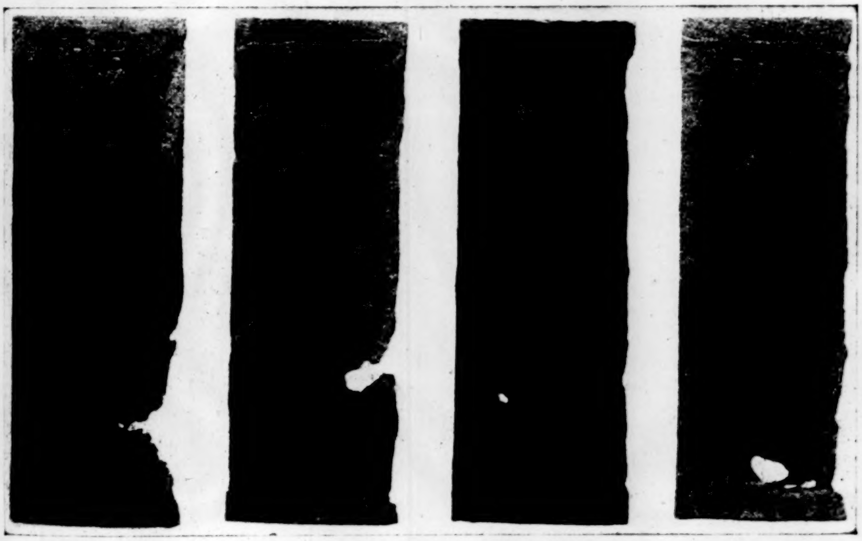
Inspection, August 6, 1925, 1890 days.



HH 12. HH 5. HH 2.

FIG. 5.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.



BB 15. BB 9. BB 6. BB 3.

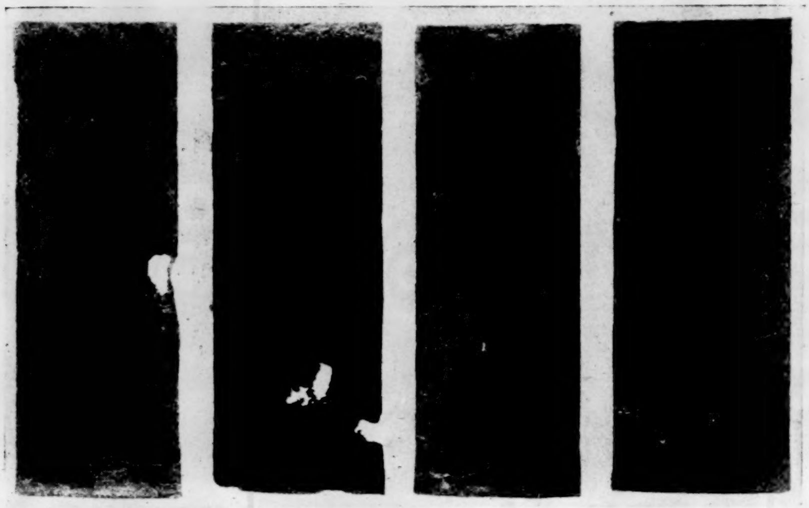
FIG. 6.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.

TT 9. TT 8. TT 6. TT 1.

FIG. 7.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

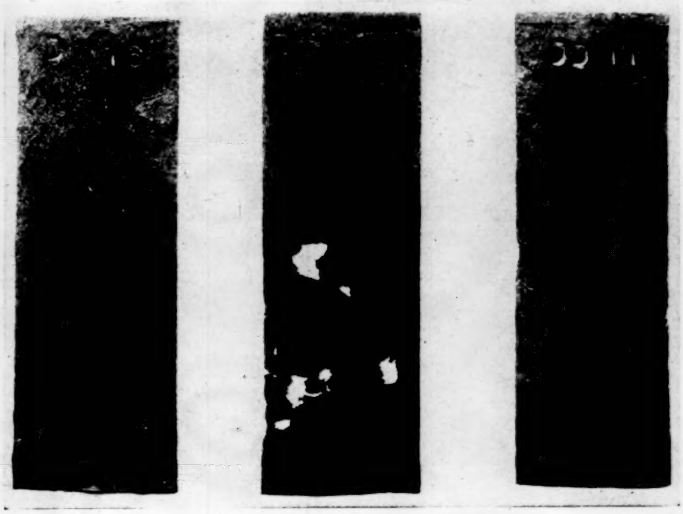
Inspection, August 6, 1925, 1890 days.



ZZ 503. ZZ 4. CC 7. ZZ 202.

FIG. 8.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

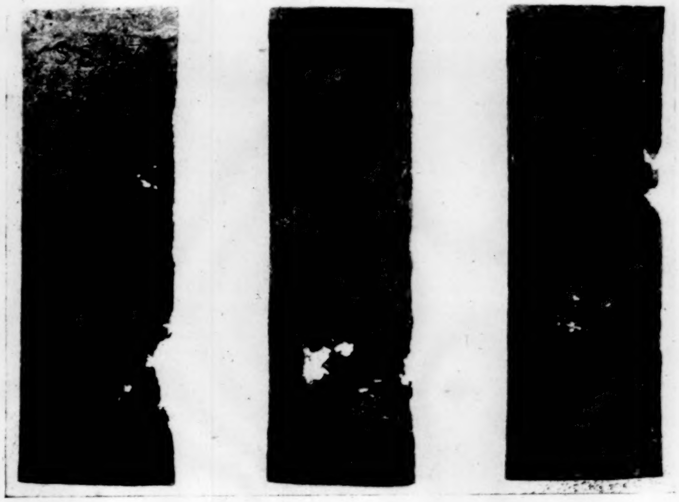
Inspection, August 6, 1925, 1890 days.



DD 16. DD 15. DD 11.

FIG. 9.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

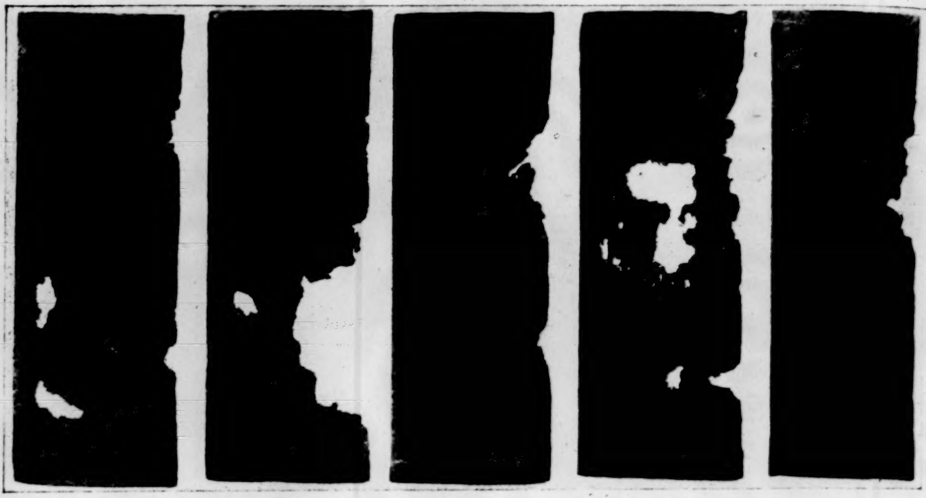
Inspection, August 6, 1925, 1890 days.



SS 17. SS 9. SS 3.

FIG. 10.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

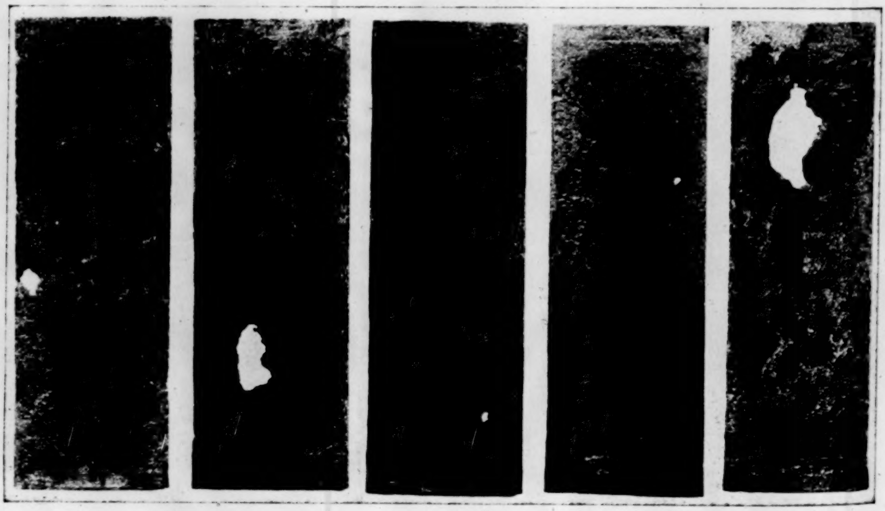
Inspection, August 6, 1925, 1890 days.



XX 35. XX 32. XX 7. XX 5. XX 3.

FIG. 11.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.



VV 32. VV 31. VV 30. VV 19. VV 1.

FIG. 12.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.

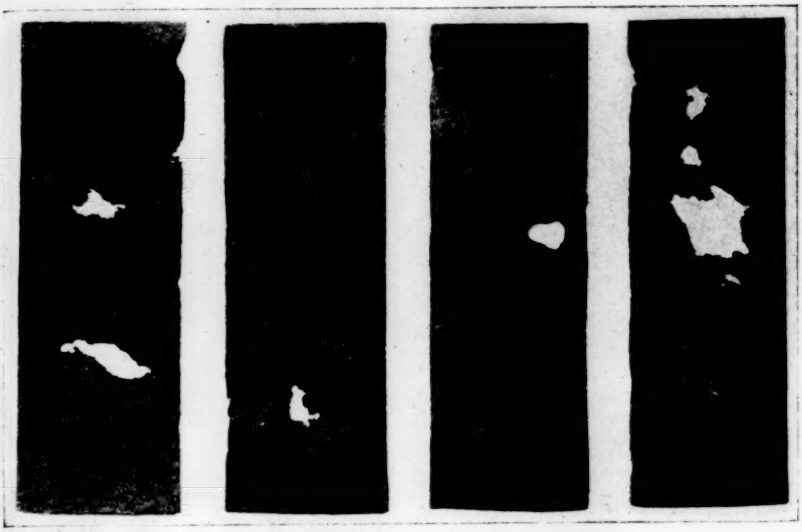


FIG. 13.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.

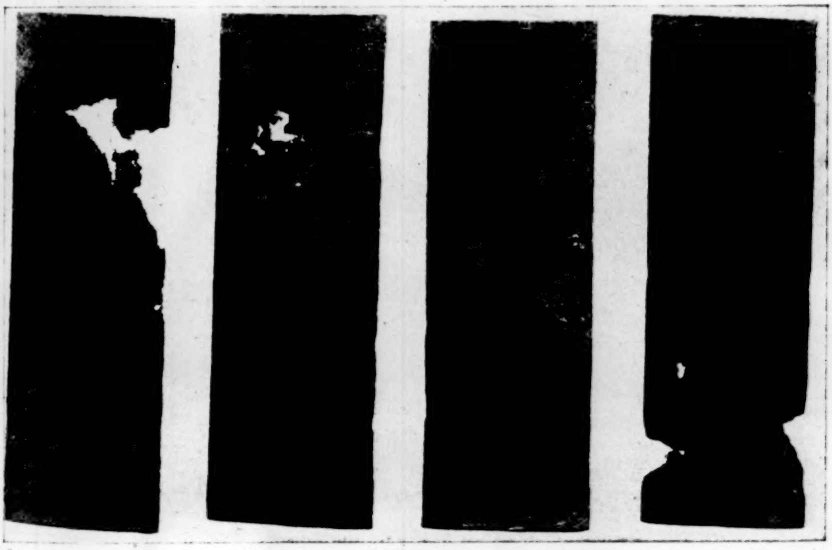


FIG. 14.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.

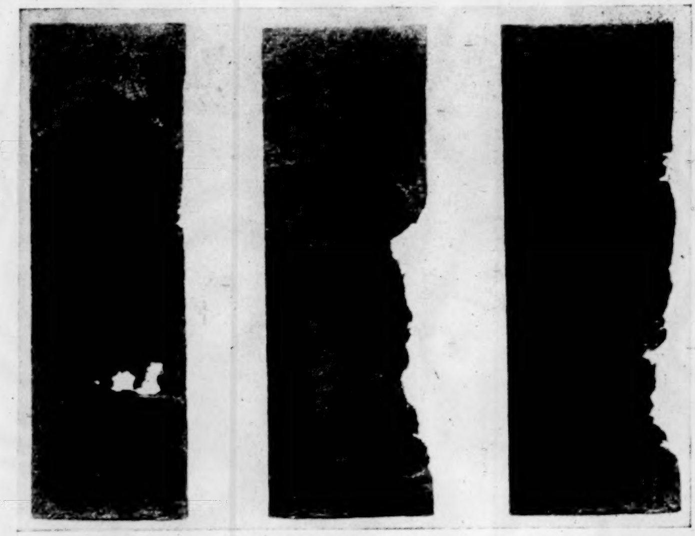


FIG. 15.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.

YY 8.
YY 8.
YY 8.
YY 8.

FIG. 16.—Failures of the No. 16 Gage Specimens in Total Immersion Tests at Naval Engineering Experiment Station, Annapolis, Md.

Inspection, August 6, 1925, 1890 days.

and two plates each with silicon about 0.23 per cent, riveted together with rivets as follows:

One row of steel rivets with copper 0.03 per cent or under;
One row of steel rivets with copper 0.25 to 0.30 per cent;
One row of puddled iron rivets with copper 0.03 or under;
One row of steel rivets, standard ship quality.

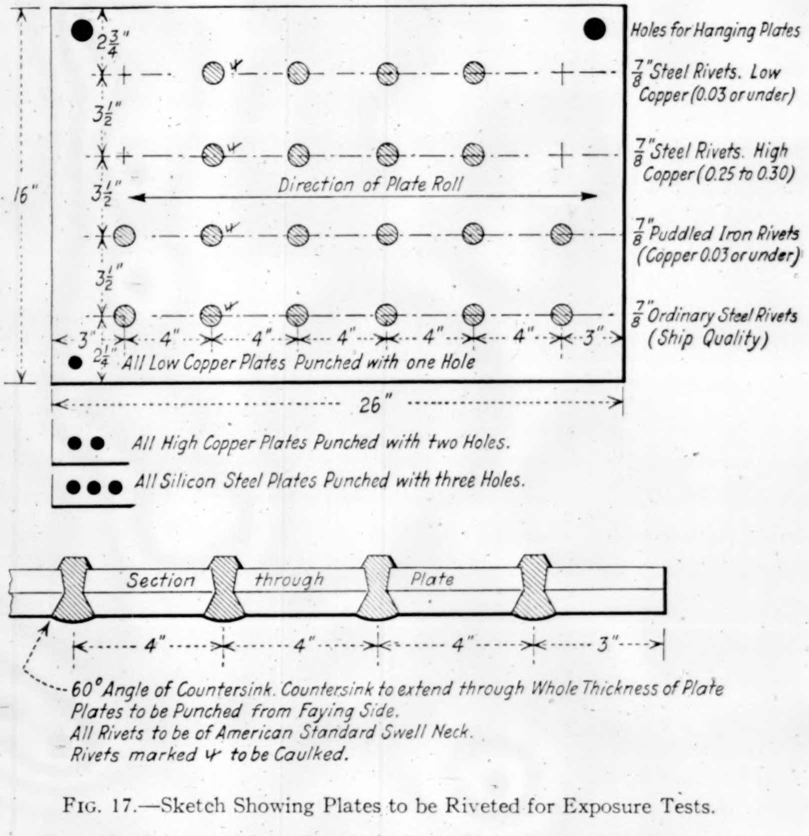

Holes for Hanging Plates
$\frac{7}{8}$" Steel Rivets. Low Copper (0.03 or under)
$\frac{7}{8}$" Steel Rivets. High Copper (0.25 to 0.30)
$\frac{7}{8}$" Puddled Iron Rivets (Copper 0.03 or under)
$\frac{7}{8}$" Ordinary Steel Rivets (Ship Quality)
$2\frac{3}{4}$"
$3\frac{1}{2}$"
$3\frac{1}{2}$"
$3\frac{1}{2}$"
$2\frac{1}{4}$"
16"
Direction of Plate Roll
3" 4" 4" 4" 4" 4" 3"
All Low Copper Plates Punched with one Hole
26"
All High Copper Plates Punched with two Holes.
All Silicon Steel Plates Punched with three Holes.
Section through Plate
4" 4" 4" 3"
60° Angle of Countersink. Countersink to extend through Whole Thickness of Plate
Plates to be Punched from Faying Side.
All Rivets to be of American Standard Swell Neck.
Rivets marked ψ to be Caulked.

FIG. 17.—Sketch Showing Plates to be Riveted for Exposure Tests.

Three pairs of plates, as follows: Low-Copper Steel; Copper-Bearing Steel; Silicon Steel.

The plates are $\frac{1}{2}$ in. thick, 16 by 26 in. in size. The low-copper plates will have one $\frac{1}{2}$-in. hole in the lower corner, the high-copper plates will have two $\frac{1}{2}$-in. holes in the lower corner, and the high-silicon plates will have three $\frac{1}{2}$-in. holes in the lower corner, for identification. All the plates will have two $\frac{7}{8}$-in. holes in the upper corners for attaching chains. The riveted test pieces will be suspended with stout chains under the dock with trap doors above, so that they can be inspected. The test plates will be totally immersed below any low tide and to insure against excessive wave action. Punchings from plates and sample rivets will be sent to the Bureau of Standards for analyses. The test pieces have been prepared by Lloyds' Register of Shipping, which has prepared a duplicate set of test pieces, similar in all respects which it will have installed at Port Arthur, Tex., as it has found from experience that the Gulf water at Port Arthur is very destructive to ship plates and rivets. The plates were assembled, punched and riveted in the presence of Mr. William Bennett of Lloyds' Register of Shipping and the chairman of the sub-sub-committee having jurisdiction over the tests.

Respectfully submitted on behalf of the sub-committee,

WILLIAM A. COOPER,
Chairman.

REPORT OF SUB-COMMITTEE VI ON SPECIFICATIONS FOR ZINC-COATED PRODUCTS

During the year Sub-Committee VI has increased its membership and considerably extended its field by taking up galvanized material other than sheets. One group in the sub-committee is studying a collection of representative samples of sherardized material with the object of developing specifications for such coatings.

Another group in the sub-committee has investigated requirements for galvanized wire and offers herewith[1] drafts for a general specification for the coating on zinc-coated (galvanized) wire, for zinc-coated (galvanized) iron and steel telephone and telegraph line wire and for zinc-coated (galvanized) iron or steel tie wire. Sub-Committee VI recommends that these three specifications be accepted for publication as tentative. This group in the sub-committee is also studying the requirements for specifications for galvanized barbed fence wire, chain link fencing, woven-wire fencing, strand wire and bond wire.

Following a request from Committee A-1 on Steel, consideration has been given to suitable specifications for the coating on galvanized steel and iron pipe. It does not appear practicable at this time, to offer a test for the physical properties of the coating. The sub-committee does, however, recommend that Committee A-5 offer to Committee A-1 and Committee A-2 on Wrought Iron the following as suitable clauses for the details therein mentioned:

> "The coating on either the inside or the outside of the pipe shall weigh not less than 2 oz. per sq. ft. of single surface."
>
> "The finished pipe shall be of first-class commercial quality, free from flaws or mechanical defects such as pin holes, cracks, blisters, and blackened sal-ammoniac or acid spots. The surface shall be free from excessive roughness or lumps."

The Tentative Specifications for Hot-Dipped Galvanized Sheets (A 93 - 24 T) have been further studied. It appears impracticable at present to formulate requirements for the base or black sheets. The various uses for galvanized sheets are being investigated, as information contributory to a review of the present tentative requirements for weights of coating for the various gages of sheets.

Sub-Committee VI recommends that the Tentative Specifications A 93 - 24 T, in their present form be offered to the Sectional Committee of the American Engineering Standards Committee, as information.

Respectfully submitted on behalf of the sub-committee,

H. E. SMITH,
Chairman.

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[1] See pp. 664–674. —ED.

REPORT OF SUB-COMMITTEE VII ON ACCELERATED TESTS

During the past year, the sub-committee has continued its study of "short-time" corrosion tests. The main purpose of this work is to find some corrosion test for coated metals which will give results indicative of what will really take place in service. It is felt that the various types of tests which have been brought to the attention of the sub-committee should be examined in considerable detail, before any of them are used in testing the sample of the various materials which are to enter into the field exposure tests being carried out by Sub-Committee VIII. The present report contains results obtained by the use of some of these "short-time" tests which have been developed for coated metals.

Materials and Tests

The coated sheet steel samples used for these tests were prepared especially for the sub-committee's use by Messrs. W. C. Randall and F. Wolfe, members of Committee A-5. The samples were approximately 7½ by 18 in. and each piece was weighed both before and after coating so that the weight of coating was known very exactly. The samples were coated by the following methods: (1) lead coated by the metal spray process; (2) zinc coated by the metal spray process; (3) zinc coated by electroplating; (4) sherardized; and (5) zinc coated by hot dipping (galvanizing).

The following members of the committee agreed to undertake the testing of samples, the test to be used being the one with which the member making the test was most familiar. No instructions were laid down by the sub-committee as to the test method. Each one was left free to conduct the test as he deemed best.

LABORATORY	TYPE OF TEST
The New Jersey Zinc Co. (W. H. Finkeldey)	Simulated atmospheric test (Wet SO_2-CO_2-air combined with water spray); described in *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 729 (1925).
Bell Telephone Laboratories, Inc. (F. F. Farnesworth)	Intermittent alternate immersion test, ammonium chloride solution; described in *Transactions*, Am. Electrochemical Soc., Vol. 45, p. 281 (1924).[a]
U. S. Bureau of Standards (T. P. Sager)	Sodium chloride "spray" test; described in U. S. Bureau of Standards *Circular No. 80*; *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 726 (1924).
Massachusetts Institute of Technology (W. G. Whitman)	Modified water "spray" test.
United States Cast Iron Pipe Co., Birmingham, Ala. (H. Y. Carson)	Combined sodium chloride and distilled water "spray."

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[a] The test as carried out for the results reported here was slightly modified by the addition of an oxidizing reagent to the solution and also as to the strength of ammonium chloride solution used.

TABLE I.—RESULTS OF SIMULATED ATMOSPHERIC TEST (REPORTED BY W. H. FINKELDEY).

Specimen No.	Material	Coating, oz. per sq. ft. of Surface	Number of Cycles	Record of Inspection[a]
2 L	Lead-sprayed Steel	1.64	1	Badly rusted. (Failure)
			13	Blisters appeared. No lead coating underneath.
			18	Very badly blistered.
9 L	Lead-sprayed Steel	3.29	1	Badly rusted. (Failure) (Removed)
13 L	Lead-sprayed Steel	1.96	1	Badly rusted. (Failure) (Removed)
9 M	Zinc-sprayed Steel	1.73	2	Rusted on one edge. (Failure)
			5	All edges rusted.
			10	Rusting from edges spreading.
			13	Rust areas on all parts of specimen.
			18	Numerous badly rusted areas. (Removed)
12 M	Zinc-sprayed Steel	1.11	5	Slight rusting on edge. (Failure)
			9	Rusted areas.
			11	Numerous badly rusted areas. (Removed)
15 M	Zinc-sprayed Steel	0.86	2	Slight rusting on edge. (Failure)
			8	Rusted areas.
			13	Numerous badly rusted areas. (Removed)
3 E	Electroplated Steel	1.43	12	Rusted. (Failure)
			18	Badly rusted. (Removed) (In general the edges and areas about the edges are not rusted.)
8 E	Electroplated Steel	0.86	10	Rusted. (Failure)
			11	Badly rusted. (Removed) (In general the edges and areas about the edges are not rusted.)
15 E	Electroplated Steel	0.80	12	Rusted areas. (Failure)
			13	Badly rusted. (Removed) (In general, the edges and areas about the edges are not rusted.)
8 S	Sherardized Steel	1.86	8	Small areas show very faint rust stains.
			16	More distinct rusting, but still not characteristic of ordinary iron rust.
			22	Rusted areas. (Failure)
			27	General rusting over entire specimen. (Removed)
9 S	Sherardized Steel	0.95	8	Edges slightly rusted. (Failure)
			10	Small rust spots.
			18	General rusting, but not severe. (Removed)
13 S	Sherardized Steel	0.90	5	Very faint rust stain.
			10	Numerous rust spots. (Failure)
			20	Badly rusted. (Removed)
5 G	Hot-dip Galvanized Steel	2.60	25	Very slightly rusted.
			26	Slightly rusted.
			33	Slightly rusted—not serious. (Removed)
10 G	Hot-dip Galvanized Steel	2.18	18	Very slightly rusted.
			28	Slightly rusted. (Failure)
			33	Slightly rusted—not serious. (Removed)
15 G	Hot-dip Galvanized Steel	2.18	25	Very slightly rusted.
			26	Slightly rusted. (Failure)
			33	Slightly rusted. (Removed)

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[a] Determination of "failure" for sheets coated by the various processes was a somewhat difficult task because of the entirely different types of failure produced by the different types of coating. The term "failure" as used in this report indicates the appearance of iron rust which is thought to be caused by the exposure and rusting of the steel base. The "quality" rather than the "quantity" of the corrosion product was taken as a criterion of "failure." There are cases where only very small areas of rusting caused a "failure" judgment of the specimen, for example, sheet 9 M, Zinc-Sprayed Steel. On the other hand, as in the case of sherardized coatings, the appearance of a light yellow corrosion product over the entire surface of the specimen was not termed "failure" because it was evident that the zinc coating was still offering excellent protection—even though in the form of an iron-zinc alloy layer which, of course, would yield a rust-colored corrosion product due to the presence of iron salt. The term "removed" indicates that the testing of the particular sample was stopped.

TABLE II.—INTERMITTENT ALTERNATE IMMERSION TEST (REPORT BY F. F. FARNESWORTH).

Specimen No.	Coating	Weight of Coating, oz. per sq. ft. of Surface	Intermittent Alternate Immersion Tests (4 Cycles per hour)					Outdoor Exposure Test
			Solution No. 1: 5-per-cent NH_4Cl 0.005 M$(NH_4)_2S_2O_8$		Solution No. 2: 5-per-cent NH_4Cl 0.025 M$(NH_4)_2S_2O_8$		Condition of Samples When Each Test Was Stopped	Condition of Samples After 302 Days Exposure
			Number of Cycles for First Corrosion	Number of Cycles When Test was Stopped	Number of Cycles for First Corrosion	Number of Cycles When Test was Stopped		
4 G	Hot-dip galvanized	2.5	...	819	...	657	No base metal failures[c]	Good.
9 G	Hot-dip galvanized	2.1	...	819	...	657	No base metal failures[c]	Good.
14 G	Hot-dip galvanized	4.7	...	819	...	657	No base metal failures[c]	Good.
1 L	Lead-sprayed	1.8	5	179	1	21	General failure of base metal	Small rust area. Darkened in color.
14 L	Lead-sprayed	1.5	5	179	1	21	General failure of base metal	Darkened in color.
4 L	Lead-sprayed	2.2	5	179	1	21	General failure of base metal	General failure.
4 M	Zinc-sprayed	1.1	150	186	146	246	Several rusted areas showing uneven coating	Darkened in color.
10 M	Zinc-sprayed	1.1	150	186	146	246	Several rusted areas showing uneven coating	Darkened in color.
14 M	Zinc-sprayed	0.8	150	186	146	246	Several rusted areas showing uneven coating	Darkened in color.
5 E	Electroplated (zinc)	0.9	186	186	246	246	Very few pinholes of rust	Good.
6 E	Electroplated (zinc)	0.8	186	186	246	246[d]	Very few pinholes of rust	Good.
12 E	Electroplated (zinc)	1.0	...	186	246	246	Very few pinholes of rust	Good.
5 S	Sherardized	0.9	...[a]	682	...	646	General rusting of base metal	General rust discoloration on one side. Not a base metal failure.
10 S	Sherardized	1.5	...	[b]	...	646	[b]	Very dark gray.
15 S	Sherardized	1.5	...	682	...	646	No positive base metal failure	Very dark gray.

[a] Due to the fact that the sherardized samples developed a "curing" or "aging" rust discoloration early in the test we were not able to determine the exact point at which failure of the base metal occurred.

[b] Sherardized Specimen No. 10 S was specially treated to show the progressive development of this "aging" rust. After a period of 89 cycles the sample was removed from the test and a strip at the upper edge painted with paraffin to arrest further attack in this area. As shown below, further areas were painted from time to time to preserve their appearance and provide successively corroded areas for later comparison:

Sample 10 S

Number of Cycles	*Color of Surface*
0	Normal
89	Very dark gray
179	Slightly rusty
269	General rust discoloration
306	Slightly darker rust

No failures of the base metal had occurred in 306 cycles.

[c] Some alloy rust had appeared.

[d] Some rusting in parallel grooves had occurred on one side of this sample, indicating gassing during plating.

Reports have been received from the first three laboratories, although in some cases the tests were not carried to completion, that is, to failure, for all of the sheets.

SIMULATED ATMOSPHERIC TEST (NEW JERSEY ZINC CO. RESEARCH LABORATORY)

Briefly, this test consists in exposing the samples in an enclosed space to a warm moist atmosphere containing approximately 1 per cent SO_2 and 5 per cent CO_2. The temperature of the enclosed space in which the specimens are placed is maintained at 53 to 55° C. by electric heaters immersed in the layer of water which covers the bottom of the container. The samples are kept for 10 hours in the corrosive atmosphere, which is constantly renewed during the course of the test, and at the end of the 10-hour period, they are washed by means of a "stiff" water spray for 2 hours after which they are scrubbed to remove loosely adhering particles and then allowed to dry for 12 hours. This series of treatments constitutes one "cycle" as given in Table I.

TABLE III.—SODIUM CHLORIDE "SPRAY" TESTS (REPORT OF T. P. SAGER).

Specimen No.	Type of Coating	Weight of Coating, oz. per sq. ft. of Surface	Hours in Salt Spray	Hours for Failure
2 G	Hot-dipped Zinc	1.85	282	No failure
7 G	Hot-dipped Zinc	....	282	No failure
12 G	Hot-dipped Zinc	2.55	282	No failure
5 L	Lead Spray	1.33	71	71
6 L	Lead Spray	1.85	95	95
11 L	Lead Spray	2.30	143	143
1 M	Zinc Spray	0.98	282	No failure
6 M	Zinc Spray	1.30	282	No failure
13 M	Zinc Spray	1.05	234	234
4 E	Electroplated Zinc	0.77	210	210
9 E	Electroplated Zinc	1.00	282	No failure
11 E	Electroplated Zinc	0.84	207	207
3 S	Sherardized Zinc	....	216	216
11 S	Sherardized Zinc	1.25	234	234
12 S	Sherardized Zinc	1.60	282	No failure

INTERMITTENT ALTERNATE IMMERSION TEST (BELL TELEPHONE LABORATORY)

This test as originally devised was for the purpose of evaluating the corrosion resistance of electroplated zinc coatings, a 2-per-cent solution of ammonium chloride was recommended. Into this solution the specimens were repeatedly immersed at 15-minute intervals until evidence of rusting of the base metal (steel sheet) was obtained. In obtaining the results reported in Table II, the test was modified slightly by the addition of an oxidizing reagent (ammonium persulfate) to the ammonium chloride solution, also by increasing the concentration of the latter. Portions of the same samples were exposed to the atmosphere on the roof of the Bell Telephone Research Laboratory for 302 days. The results of this test are also included.

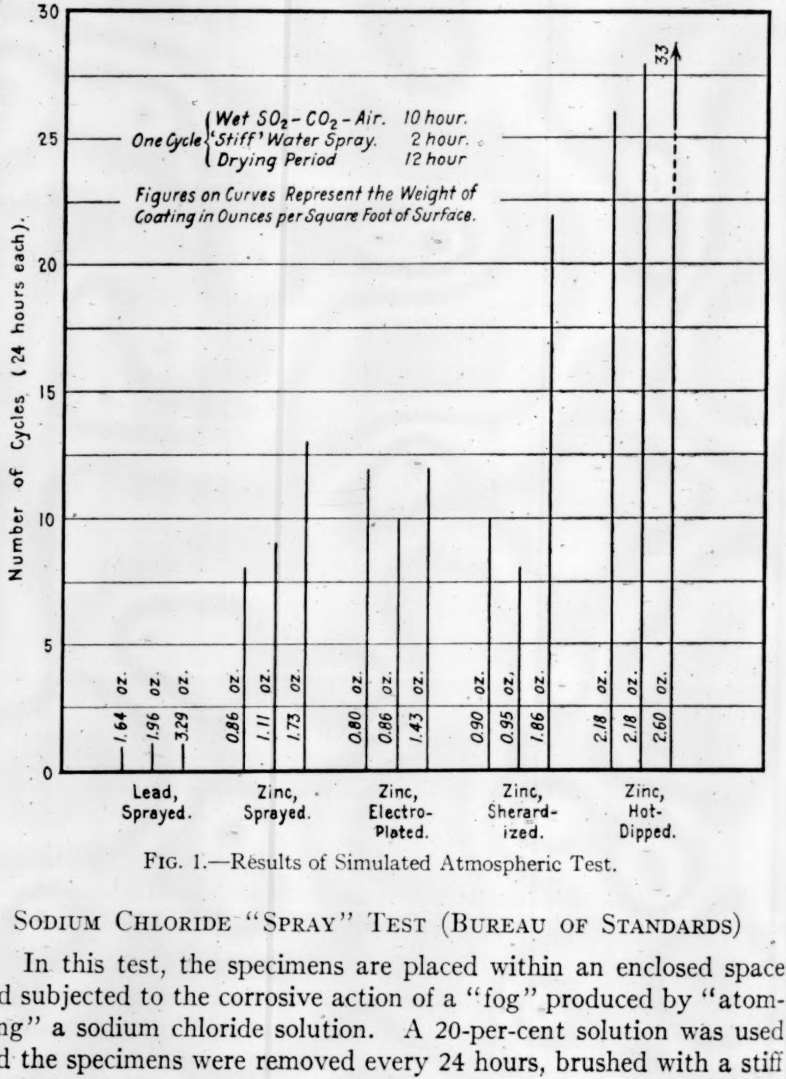

FIG. 1.—Results of Simulated Atmospheric Test.

SODIUM CHLORIDE "SPRAY" TEST (BUREAU OF STANDARDS)

In this test, the specimens are placed within an enclosed space and subjected to the corrosive action of a "fog" produced by "atomizing" a sodium chloride solution. A 20-per-cent solution was used and the specimens were removed every 24 hours, brushed with a stiff bristle brush and examined. The results obtained are summarized in Table III.

In all accelerated corrosion tests, the determination of the end point is often a matter of some uncertainty. Not until the rusting of the base metal (sheet steel) is well pronounced can it be stated with certainty that the coating has been perforated by the corroding agent. This is especially true of zinc coating of the hot-dipped and sherardized type, in which the zinc is alloyed with a considerable amount of iron.

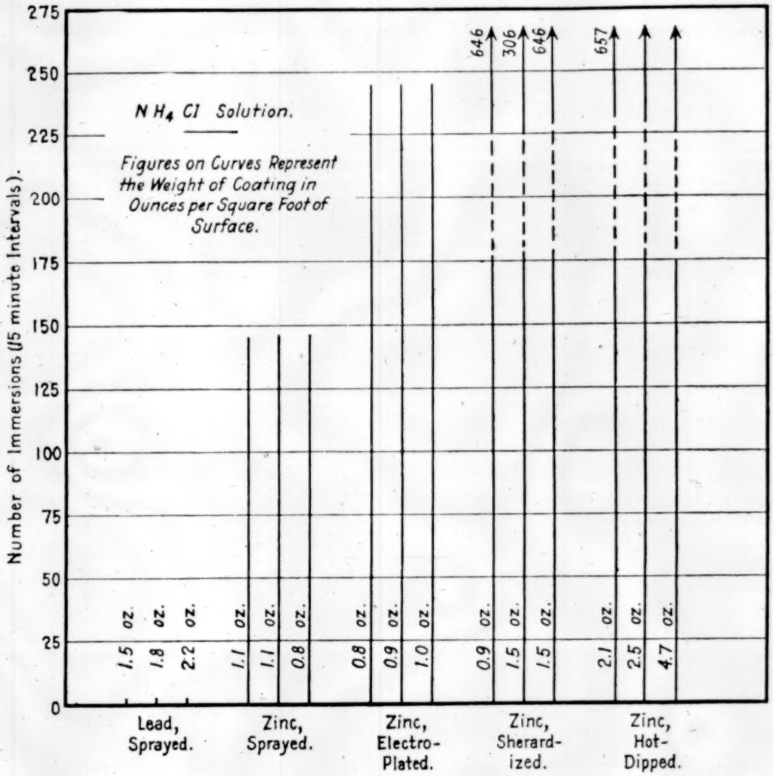

Fig. 2.—Results of Intermittent Immersion Test.

The error introduced from this source will vary considerably with different observers and some of the differences to be noted in the results reported here may be attributed to this cause rather than to the test itself.

The results obtained are shown in graphical form in Figs. 1, 2, and 3. The arrow indicates, in each case, that failure of the coating had not occurred at the time the test was stopped, in all other cases the specimen had failed by perforation of the coating and rusting of the steel base. In plotting the results of the intermittent immersion test (Table II), the results obtained with solution No. 2 were used. The results obtained with the metal-sprayed specimens indicated (Table I) that the edges of the sheets had been imperfectly coated. The life of the metal-sprayed specimens was therefore taken as the number of exposure cycles required to produce well-developed rusted areas at some distance from the edge. These were the values used in Fig. 1 rather than the time at which rusting was first observed on or near the edges of the specimens.

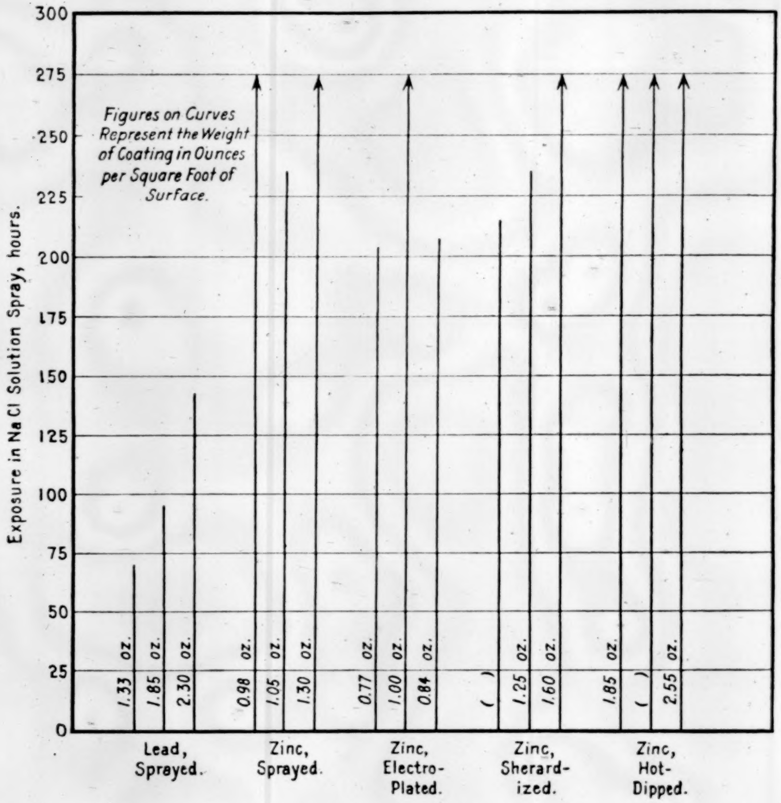

FIG. 3.—Results of Salt Spray Test.

SUMMARY

The sub-committee feels that at the present stage of the work, no sweeping conclusions as to the relative merits of these particular accelerated tests are warranted. It is evident, however, from Figs.

1, 2, and 3, that the three tests differ rather decidedly in the severity of the corrosive attack. The results also show that, although the five types of coatings would be placed in the same general order according to the results of the three tests, the order would not exactly be the same in each case. The need for further study of these and other proposed accelerated corrosion tests to be carried out on *known* materials is evident. Further work is already under way in the sub-committee.

Respectfully submitted on behalf of the sub-committee,

H. S. RAWDON,
Chairman.

REPORT OF SUB-COMMITTEE VIII ON TESTS OF METALLIC-COATED PRODUCTS

The sub-committee has made substantial progress during the past year in the development of the program of field tests on metallic-coated products reported in detail at the last annual meeting. The atmospheric tests on galvanized sheet metal has been started, the specimens being placed on the test racks at Brunot Island, Pittsburgh, Pa., on April 21, 1926; at the Juniata Shops of the Pennsylvania Railroad System, Altoona, Pa., on April 22, 1926; at Penn State College, State College, Pa., on April 23, 1926; at Fort Hancock Military Reservation, Sandy Hook, N. J., on May 20, 1926; and at the Marine Naval Base, Key West, Fla., on June 11, 1926.

The detail data for the individual test specimens, which will include the weights of base metal and zinc coating, and the spot tests made at the U. S. Bureau of Standards, Washington, D. C., together with other laboratory information will all be incorporated in the next report of the sub-committee.

The collection of the materials for the wire and fencing tests is now in progress, and the collection of the hardware, pipe, conduit and structural shape material will be undertaken within a very short time.

Arrangements have been made for collection, storage, and inspection of the wire and fencing materials at the plant of the General Electric Co., Schenectady, N. Y., and the place of collection and storage of the materials in the hardware group will be announced in a short time.

The program for tests on hardware, tubes and fitting material as revised and approved by the committee is submitted herewith for information.

CONDUITS

There shall be exposed at each location three 18-in. sections of 1-in. conduit, without threading, with each of the following coatings:

Hot Galvanizing,
Sherardizing,
Electrogalvanizing,
Calorizing,
Hot-dip Aluminum
Cadmium Plating,
Lead Coating.

HOT-WELDED PIPE

There shall be exposed at each location three 18-in. sections of 2-in. hot-welded pipe in commercial standard practice base metal with each of the following coatings:

Hot galvanizing,
Sherardizing,
Electrogalvanizing,
Hot-dip Aluminum,
Lead Coating.

BOLTS

There shall be exposed at each location three samples of each of the following sizes of rough forged commercial hot-pressed bolts and nuts, in our commercial grade of base material:

⅜ by 1½-in. Square-Head Bolt and Square-Head Nut.
½ by 2½-in. Square-Head Bolt and Hex-Head Nut.
⅝ by 2½-in. Square-Head Bolt and Hex-Head Nut.
1¼ by 6-in. Square-Head Bolt and Square-Head Nut.

These are included in each of the following coatings:

Hot Galvanizing,
Sherardizing,
Cadmium Plating,
Electrogalvanizing.

HARDWARE AND FITTINGS

At each location there shall be exposed three samples of each of the articles listed below, in each of the specified coatings:

Malleable-Iron Suspension Clamp No. 3122, Locke Insulator Co.
Malleable-Iron Line Material Clamp, Ohio Brass Co.
Gray-Iron Suspension Clamp No. 3122, Locke Insulator Co.
Forged-Steel Tower Fitting No. 8433, Locke Insulator Co.
Cold-Rolled Steel, Standard Form Door Hinge, Stanley Works
Gray-Iron Elbows, ¾ in. in diameter, 6 in. of pipe with same coating as elbow, bare threads on pipe, threaded after coating, screwed into one end of elbow, elbow threads to be cut before coating, with no recutting.
Sheet Steel Knockout Box.

The coatings specified are the following:

Hot Galvanizing,
Sherardizing,
Cadmium Plating,
Electrogalvanizing,
Parkerizing,
Hot-dip Aluminum Tentatively,
Sprayed Zinc.

ROOFING NAILS AND WOOD SCREWS

At each location there shall be exposed sufficient samples of 1-in. roofing nails and No. 14 gage 2-in. round-head wood screws, in each of the coatings listed below, driven or screwed into the wooden cross arms, to permit five being withdrawn at each semi-annual inspection for a period of twenty years:

Hot-dip Galvanizing,
Sherardizing,
Electrogalvanizing,
Cadmium Plating,
Sprayed Zinc,
Parkerizing,
Hot-dip Aluminum.

STRUCTURAL SHAPES

Flats:

There shall be exposed at each location 3 samples each 18 in. long of each of the following sizes of flat shapes, in each of the coatings specified, with base metal conforming to A.S.T.M. Standard Specifications for Structural Steel for Buildings (A 9 - 24) in both plain and copper-bearing steel:

$2\frac{1}{2}$ in. by No. 14 gage.
3 by $\frac{1}{4}$ in.

The coatings specified are the following:

Hot Galvanizing,
Electrogalvanizing,
Sprayed Zinc,
Cadmium Plating,
Hot-dip Aluminum.

Angles:

There shall be exposed at each location 3 samples each 18 in. long of the following sizes of angles in structural shapes, in each of the coatings specified, with base metal conforming to A.S.T.M. Standard Specifications for Structural Steel for Buildings (A 9 - 24) in both plain and copper bearing steel:

$1\frac{1}{2}$ by $1\frac{1}{2}$ by $\frac{1}{8}$ in.
2 by $1\frac{1}{2}$ by $\frac{3}{16}$ in.
3 by 3 by $\frac{1}{4}$ in.

The coatings specified are the following:

Hot Galvanizing
Electrogalvanizing,
Hot-dip Aluminum,
Sprayed Zinc.

T-Bars:

There shall be exposed at each location 3 samples each 18 in. long of Standard T Bars $2\frac{3}{4}$ by $1\frac{3}{4}$ in., in each coating listed, with base metal conforming to A.S.T.M. Standard Specifications for Structural Steel for Buildings (A 9 - 24) in both plain and copper-bearing metal:

Hot Galvanizing,
Electrogalvanizing,
Hot-dip Aluminum,
Sprayed Zinc.

Window Frame Sections:

There shall be exposed at each location 3 samples each 18 in. long of each of the window frame sections listed below, with standard base material, in each of the coatings specified:

Standard Window Frame Section
  Catalog No. 161 of Detroit Steel Products Co.
Standard Window Frame Section
  Catalog No. 792 of Detroit Steel Products Co.

The coatings specified are the following:

Hot Galvanizing,
Sherardizing,
Cadmium Plating
Electrogalvanizing,
Sprayed Zinc,
Parkerizing,
Hot-dip Aluminum.

The Inspection Committee, whose duty it will be to inspect and report upon these tests at the different locations has been appointed and consists of the following members:

F. A. Hull, *Chairman*

Galvanized Sheets	*Wire and Fencing*
M. E. McDonnell, Vice-Chairman	C. D. Hocker, Vice-Chairman
W. J. Beck	F. C. Elder
W. C. Carroll	L. W. Hopkins
H. S. Rawdon	H. J. Horn
G. A. Reinhard	Maro Johnson
H. E. Smith	M. E. McDonnell
E. S. Taylerson	J. L. Schueler
C. S. Trewin	C. S. Trewin

Pipe Fittings and Hardware

R. L. Duff, Vice-Chairman
V. F. Hammel
C. D. Hocker
W. C. Randall
H. S. Rawdon
C. S. Trewin

The sub-committee wishes to record its appreciation of the very substantial cooperation rendered by the various producers of galvanized sheets in furnishing the specimens for the tests, and to the American Sheet and Tin Plate Co. for assistance in fabricating and storing the test specimens under the direction of the special sub-committee. Also to the Cyclone Fence Co. and the Page Steel and Wire Co. for furnishing and erecting with their field engineering forces suitable fences for inclosing the racks at the various test locations.

Respectfully submitted on behalf of the sub-committee,

F. A. HULL,
Chairman.

REPORT OF COMMITTEE A-6
ON
MAGNETIC PROPERTIES

The tentative revision of the Standard Methods of Test for Magnetic Properties of Iron and Steel (A 34 - 24)[1] as appended hereto[2] as complete tentative methods is proposed primarily with the object of making the test procedure for obtaining normal induction data more specific both with respect to test methods and test specimens. In addition, certain features have been incorporated dealing with the nickel alloys which have been developed for magnetic purposes.

Standard magnetic tests of core materials for use in audio-frequency transformers and choke coils are under consideration but are not yet in shape for adoption. Until such time as these specifications are ready to propose for adoption, Committee A-6 will be glad to offer or receive suggestions for suitable tests for this class of material.

No changes have been made in the methods of testing for core loss.

This report has been submitted to letter ballot of the committee, which consists of 12 members, of whom 9 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

THOMAS SPOONER,
Chairman.

R. L. SANFORD,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Test for Magnetic Properties of Iron and Steel were accepted for publication as complete tentative methods to replace, when adopted, the present standard methods. The tentative methods appear on page 675.

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[1] 1924 Book of A.S.T.M. Standards.

[2] See p. 675.—ED.

REPORT OF COMMITTEE A-8
ON
MAGNETIC ANALYSIS

Committee A-8 has held two meetings during the past year in addition to that held at the time of the annual meeting of the Society.

Committee A-8 was organized in 1918 for the purpose of systematically examining into the relation between the magnetic and other physical properties of ferrous materials. That a relation of a kind existed had been known for a very long time. The definiteness of the relation, the extent to which it might be readily utilized in manufacturing and inspection operations and the adequacy of the available testing equipment were all open to serious question.

From the practical point of view, a successful issue of an investigation in this field is alluring. It proposes a method of inspection which leaves the product unchanged or marred in any degree. It would therefore permit, where expedient on economic grounds, of one hundred per cent examination of material.

Upon its organization, Committee A-8 formed a sub-committee, the functions of which were to be essentially those of research. After considerable study, this sub-committee decided that an immediately important practical problem centered about a method of predetermining the cutting properties of tools. Drills were finally decided upon as an outstanding conveniently handled tool of this class and the commercial importance of high-speed steel dictated the selection of drills of this composition. The sub-committee became known as the Sub-Committee on Drill Testing.

The initial investigation of the sub-committee involved the examination of $\frac{1}{2}$-in. taper-shank high-speed twist drills. These were formed from rods specially rolled for the purpose, which were first checked for uniformity by magnetic methods. The forming program permitted such variations in dimensions as are normal to production operations. A wide range of heat-treatment was represented, embracing some without pyrometer control. In addition to the drills from the selected rods there were included a few of an analysis slightly different as well as several carbon steel drills. In all, the drills numbered fifty-two.

The drills were tested for magnetic properties by several test methods both before and after heat treatment. In addition, after heat treatment, the drills were subjected to microscopic examination and hardness and cutting tests. The cutting tests involved the drilling of four materials of widely different characteristics. The results may be summarized by the following quotation from the report of the committee for the year 1923.

> "From the standpoint of a correlation of magnetic and mechanical characteristics, the test results so far obtained are to quite an extent negative in character but some promise is found in results obtained by one of the members under alternating magnetomotive forces. . . . In some instances the agreement is striking, and as the procedure employed seems capable of considerable refinement, it is the opinion of the sub-committee that the work should be continued. It is proposed to obtain a new lot of drills and to make further tests with special reference to the type of test mentioned above."

In a paper presented in 1924,[1] W. B. Kouwenhoven, a member of the sub-committee, described methods of magnetic inspection to which these drills were subjected and outlined bases of correlation between magnetic and other properties. While these data are inconclusive from the correlation standpoint, they represented progress of a definite order.

In accordance with the decision outlined in its report for 1923, the committee undertook the examination of a new lot of drills. These were of $\frac{21}{32}$-in. high-speed steel with welded carbon-steel shank, made up under a variety of heat-treatments. A very considerable amount of investigation was accomplished on these drills during which a much clearer idea was obtained as to the actual magnetic properties measured under the various forms of test, which assisted materially in test method development. A rough basis of correlation was worked out, founded upon the heat-treatment data. However, it appeared that some of these data represented nominal rather than actual temperature values, or else the time-temperature factor was highly variable. It became increasingly apparent that the results the committee desired to obtain demanded a more careful and fundamental method of attack with every operation under rigid control, if satisfactory conclusions were to be reached. It was therefore decided to hold further drill tests in abeyance in favor of an investigation of the inherent magnetic and electrical characteristics of high-speed steel specimens of uniform section. It was considered that this procedure would permit better control and knowledge of the variables involved and allow the exercise of unusual care in the thermal treatment. For the carrying out of the further program, the Westinghouse Electric and Manufacturing Co. very kindly undertook to supply some 150 lb. of $\frac{1}{2}$-in. square high-speed steel.

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[1] W. B. Kouwenhoven, "Magnetic Tests of A.S.T.M. Drills," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 635 (1924).

Appended to this report[1] is a paper entitled "The Magnetic Analysis of High-Speed Steel" by Mr. Thomas Spooner, a member of the committee. This paper presents the results obtained in the investigation of the bars mentioned. The data offered by Mr. Spooner were in very large part obtained under his immediate supervision, credit being given in the paper to those obtained by other members.

While this paper is to be considered in the light of a report on progress, the results obtained are such as to justify the committee expressing the opinion that there is a definite and practically useful correlation between the magnetic and other physical properties of this steel. It is true that data necessary to directly demonstrate the correlation between magnetic and cutting properties of tools is yet to be obtained. However, it will be apparent that since, other things being equal, the latter are functions of the heat-treatments to which the material is subjected, this naturally may be expected to follow in a practical sense.

The results given here indicate that the magnetic characteristics provide a very sensitive means for determining the reponse, or lack of response, of material to a heat-treatment process, once information as to the nature of the normal response is obtained. They also apparently show that variations not discernible by the more commonly used methods of examination may be determined. An important use brought out in the paper concerns the utility of the magnetic test method in studying the effects of time and temperature and the changes due to aging. It is hoped that several other members of the committee who are now carrying out further tests on this same material, in addition to those made intermediate in the treatment, will have final test data by the time of the annual meeting.

Not only do the data now in hand indicate a useful correlation but the point may be stressed that the methods of magnetic test used in this investigation are in large measure new in their application and seem capable of further development for the examination of a wide range of physical characteristics in the field of ferrous metallurgy. The use of alternating current for magnetization permits of the ready determination of certain characteristics which have been by no means so quickly and easily obtained under direct-current magnetization, so largely used hitherto. The selection of a value of magnetizing force which does not over-emphasize the effect of incidental internal stresses is touched upon briefly in the paper, but is without doubt an important contributing element to the success thus far obtained.

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[1] See *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, p. 116 (1926).—ED.

Committee A-8 feels gratified that its report for this year is one that demonstrates very substantial progress in the work allotted to it. The investigation in its charge will be carried forward. It will be rather generally conceded that a method of test that does not modify the material tested offers unique advantages over many other forms of inspection. There are fields of usefulness for which the present degree of advancement of magnetic analysis is not yet adequate, but that is a matter, it would appear, of time and development only. The members of the Society can assist by studying into the situation more closely and deciding in how far it is to their interest to bring this art to its full fruition. What is needed more than anything else is an increase in the number of workers in this field.

This report has been submitted to letter ballot of the committee, which consists of 11 members, of whom 8 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

FRANK P. FAHY,
Chairman.

R. L. SANFORD,
Secretary.

[For a Discussion on Magnetic Analysis, including a discussion of this report, see page 155 of Part II of the Proceedings.—ED.]

REPORT OF COMMITTEE B-1
ON
COPPER WIRE

When Committee W, the forerunner of Committee B-1, started preparing specifications for copper wire, there were no fundamental standards for copper actually defined and accepted, although there were values for resistivity and for unit weight which were commonly used in this country. These values were used as the basis of the specifications adopted by our Society. In 1913, the International Electrotechnical Commission adopted definitions of the "Annealed Copper Standard" which gradually became the accepted standard of the copper industry. These have been used in our specifications, except that unit weight for the Annealed Copper Standard is stated as density, whereas our specifications have continued definition of unit weight as specific gravity. For practical purposes, the two may be accepted as equal—the use of the two methods of definition resulting in a difference of less than 0.2 per cent and, hence, much less than the variations permissible under the specifications. Committee B-1 feels that there should not be even this minor departure from an accepted standard and that all specifications containing a definition of unit weight should be changed to the basis of density, so as to be in exact agreement with the Annealed Copper Standard. The committee, therefore, recommends that the standard specifications concerned be amended tentatively, with the expectation that next year the standards may be voted upon in time for publication in the new issue of the Book of Standards. It is also recommended that certain of the tentative specifications be similarly amended and continued as tentative, while one tentative specification is recommended for amendment and advancement to standard. The details of the changes will be included in their proper place in later references.

One of the specifications so to be tentatively amended is B 47 – 25 covering Copper Trolley Wire, which has been prepared jointly by our Society and the American Electric Railway Association. The change has, in fact, been suggested by the Railway association, with a committee of which a sub-committee of B-1 has been in continued conference. It is expected that the Railway Association will consider the same changes that are herein proposed, so that the specifications of the two bodies may continue to be identical and hence may be offered for approval as American Standard by the American Engineering Standards Committee. Steps had been taken to present these specifications to the American Engineering Standards Committee this year, but this has been postponed to await final action on the changes proposed so as to avoid the need for amendment immediately after approval by the Standards Committee.

The Tentative Specifications for Bronze Trolley Wire (B 9 – 25 T) are still under consideration by the joint committee of our Society and of the Railway Association. It has been agreed to recommend the amendment of these specifications to include a definition of unit weight on the basis of density and to make the corresponding changes in weights. It is also recommended that the maximum resistivities permitted be expressed in the terms "lb. per mile-ohm" instead of "ohms per meter-gram" so as to make them uniform with all the copper wire specifications and in agreement with usual commercial practice. These specifications should continue tentative to permit further conference with the Railway Association on the twist test requirement.

In both the copper and the alloy trolley wire specifications, a change is recommended in the stated actual area of 300,000 cir. mils size. The circular millage is an approximation only whereas the stated actual area should be exact. This is the case for the other sections but the presently stated area of the largest section corresponds exactly to 300,000 cir. mils instead of being the actual area of the section derived by calculation or planimeter measurement. While the change made is so slight as to be practically negligible, the committee feels it should be made so that the data will be accurate and that all sections will be defined in the same manner.

Last year, reference was made to the organization of a sectional committee under the Rules of Procedure of the American Engineering Standards Committee to consider the specifications for Hard-Drawn and for Medium-Hard-Drawn Copper Wire (B 1 – 23 and B 2 – 15). The committee membership has practically been completed and the new members have been added to Committee B-1 so that the membership of the sectional committee may be the same as that of Committee B-1 and so simplify the reporting of the work. The enlarged committee has held one meeting and hopes shortly to hold others as the outcome of which conclusions regarding these specifications may be reached satisfactory to all interests concerned.

Tentative Revisions of Existing Standards

Standard Specifications for Hard-Drawn Copper Wire (B 1 – 23).[1] —*Section 6.*—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "For the purpose of calculating weights, cross-sections, etc., the [specific gravity] *density* of copper shall be taken as 8.89 *g. per cu. cm.* at 20° C. (*68° F.*) (Note 4)."

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[1] 1924 Book A.S.T.M. Standards.

Change the explanatory note applying to this section to read as follows:

"Unit weights were formerly defined in these specifications on the basis of specific gravity of copper. This has been changed to basis of density to agree literally with the definition of the Annealed Copper Standard adopted by the International Electrotechnical Commission."

Standard Specifications for Medium Hard-Drawn Copper Wire (*B 2 - 15*).[1]—These specifications have been rewritten as to form so as to bring them in line with the Standard Specifications for Hard-Drawn Copper Wire (B 1 - 23), which specifications had been revised as to form in accordance with the Regulations Governing the Form but not the Substance of Standards prior to the publication of the 1924 Book of A.S.T.M. Standards.

Section 5 (Section 6 of the redrafted specifications).—Make the same change as in Section 6 of Specifications B 1 - 23 above.

Change the explanatory note applying to this section to agree with the explanatory note to Section 6 of Specifications B 1 - 23 given above.

Standard Specifications for Soft or Annealed Copper Wire (*B 3 - 15*).[1]—These specifications have been rewritten as to form so as to bring them in line with the Standard Specifications for Hard-Drawn Copper Wire (B 1 - 23).

Section 5 (Section 6 of the redrafted specifications).—Make the same change as in Section 6 of Specifications B 1 - 23 above.

Change the explanatory note applying to this section to agree with the explanatory note to Section 6 of Specifications B 1 - 23 given above.

Standard Specifications for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard, or Soft (*B 8 - 21*).[1]—

Section 6 (*first sentence*).—Make the same change as in Section 6 of Specifications B 1 - 23 above.

Standard Specifications for Round and Grooved Hard-Drawn Copper Trolley Wire (*B 47 - 25*).[2]—

Section 8.—Make the same change as in Section 6 of Specifications B 1 - 23 above.

Figure 1.—Change the figures for Actual Area of 300,000 cir. mils size of grooved wire from 0.2356 sq. in. to 0.2355 sq. in.

Change the figures for calculated weight of grooved wire from 4786, 3382, 2669 and 2201 lb. to 4792, 3389, 2674 and 2205 lb., respectively.

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[1] 1924 Book of A.S.T.M. Standards.

[2] A.S.T.M. Standards Adopted in 1925.

Section 11 (a).—Change the figures for Actual Area of 300,000 cir. mils size of grooved wire from 0.2356 sq. in. to 0.2355 sq. in.

Change the figures for calculated weight of grooved wire from 4786, 3382, 2669 and 2201 lb. to 4792, 3389, 2674 and 2205 lb., respectively.

TENTATIVE STANDARD REVISED AND ADVANCED TO STANDARD

Tentative Specifications for Hot-Rolled Copper Rods for Wire Drawing (B 49 - 23 T).[1]—

Section 7.—Make the same change as in Section 6 of Specifications B 1 - 23 above.

It is recommended that the specifications as revised be advanced to standard.

TENTATIVE STANDARDS REVISED AND CONTINUED AS TENTATIVE

Tentative Specifications for Bronze Trolley Wire (B 9 - 25 T).[2]—

Section 5.—Change the second paragraph to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "High-strength wire shall not exceed in resistivity [0.38320 ohms per meter gram] *2188 lb. per mile-ohm.* Medium-strength wire shall not exceed in resistivity [0.23574 ohms per meter gram] *1346 lb. per mile-ohm.*

Section 8.—Add a new Section 8 to read as follows, renumbering the subsequent sections accordingly:

> "For the purpose of calculating weights, cross-sections, etc., the density of the bronze shall be taken as 8.89 g. per cu. cm. at 20° C. (68° F.).[a]"
>
> "[a] Bronze trolley wire is an alloy as commonly produced of not less than 98 per cent copper with other metals. Determinations of the density of these alloys indicate, as might be expected, an average density practically the same as that found for copper."

Figure 1.—Change the figures for Actual Area of 300,000 cir. mils size of grooved wire from 0.2356 sq. in. to 0.2355 sq. in.

Change the figures for calculated weight of grooved wire from 4786, 3382, 2669 and 2201 lb. to 4792, 3389, 2674 and 2205 lb., respectively.

Section 10 (a).—Change the figures for Actual Area of 300,000 cir. mils size of grooved wire from 0.2356 sq. in. to 0.2355 sq. in.

Change the figures for calculated weight of grooved wire from 4786, 3382, 2669 and 2201 lb. to 4792, 3389, 2674 and 2205 lb., respectively.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 585 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 141.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 578 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 132.

Tentative Specifications for Soft Rectangular Copper Wire (B 48 - 23 T).[1]—

Section 8.—Make the same change as in Section 6 of Specifications B 1 - 23 above.

Change the explanatory note applying to this section to agree with the explanatory note to Section 6 of Specifications B 1 - 23 given above.

All of the recommendations have been referred to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. TENTATIVE REVISIONS OF EXISTING SPECIFICATIONS			
1. For Hard-Drawn Copper Wire (B 1 - 23)	13	0	1
2. For Medium Hard-Drawn Copper Wire (B 2 - 15)	13	0	1
3. For Soft or Annealed Copper Wire (B 3 - 15)	12	0	2
4. For Bare Concentric-Lay Copper Cable: Hard, Medium-Hard or Soft (B 8 - 21)	11	0	3
5. For Round and Grooved Hard-Drawn Copper Trolley Wire (B 47 - 25)	11	0	3
II. TENTATIVE STANDARD REVISED AND ADVANCED TO STANDARD			
6. Tentative Specifications for Hot-Rolled Copper Rods for Wire Drawing (B 49 - 23 T)	12	0	2
III. TENTATIVE STANDARDS REVISED AND CONTINUED AS TENTATIVE			
7. Tentative Specifications for Bronze Trolley Wire (B 9 - 25 T)	10	0	4
8. Tentative Specifications for Soft Rectangular Copper Wire (B 48 - 23 T)	12	0	2

In accordance with the regulations of the Society, an election has been held and the present chairman continued in office.

This report has been submitted to letter ballot of the committee, which consists of 14 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Hard-Drawn Copper Wire; for Medium Hard-Drawn Copper Wire; for Soft or Annealed Copper Wire; for Bare Concentric-Lay Copper Cable: Hard, Medium-Hard or Soft; and for Round and Grooved Hard-Drawn Copper Trolley Wire were accepted for publication as tentative and appear on pages 1017 to 1018.

The Tentative Specifications for Hot-Rolled Copper Rods for Wire Drawing, amended as recommended in the report, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed revisions of the Tentative Specifications for Bronze Trolley Wire; and for Soft Rectangular Copper Wire were accepted. The tentative standards as thus revised appear on pages 682 to 690.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 581 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 137.

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS

During the past year the following work has been accomplished by the committee: Five new tentative standards have been prepared covering aluminum-bronze castings; the alloy: copper 88 per cent, tin 8 per cent, zinc 4 per cent; steam or valve bronze; composition brass or ounce metal and aluminum base sand-casting alloy ingots. Revisions have been suggested in the Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 23) and of Bronze Bearing Metal (B 46 – 23); and also of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 – 25 T). The Tentative Specifications for Aluminum Ingots for Remelting (B 24 – 25 T), for Aluminum Sheet (B 25 – 19 T), and for Aluminum-Base Alloy Sand Castings (B 26 – 25 T) have been revised, while the Tentative Specifications for White Metal Bearing Alloys (known commercially as "Babbitt Metal") (B 23 – 18 T) and for Aluminum for Use in the Manufacture of Iron and Steel (B 37 – 20 T) are recommended for advancement to standard.

In addition appendices have been prepared covering (1) the "Fluidity Tests of White-Metal Bearing Alloys," a paper by E. R. Darby, and (2) "The Properties of High-Strength Aluminum Casting Alloys," prepared by Sub-Committee VIII on Light Metals and Alloys.

The details of the work of the committee can best be given by reference to the reports of the various sub-committees as presented at the last meeting of the committee, held March 19. The recommendations as set forth in the description of the activities of the several sub-committees are the recommendations of Committee B-2 to the Society.

SUB-COMMITTEE I ON PURE METALS IN INGOT FORM

The question has been raised as to the necessity for a specification covering fire-refined copper. It has been decided to draw up such tentative specifications for the consideration of the committee and a sub-sub-committee has accordingly been appointed to take this work in hand.

It is recommended that the revisions of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and

Ingot Bars (B 4 – 13) and for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (B 5 – 13) accepted at the 1925 annual meeting, dealing with the shapes and sizes of wire bars, be continued as tentative for another year.

Sub-Committee II on Wrought Metals and Alloys

During the year, the specifications under the jurisdiction of this sub-committee have been reviewed. The question of the arsenic content of copper plates specified in the Standard Specifications for Copper Plates for Locomotive Fireboxes (B 11 – 18) was discussed with reference to bringing the requirements into agreement with the British specifications, but no action has been taken. The committee is securing information on the use of copper pipe conforming to the Standard Specifications for Copper Pipe, Standard Sizes (B 42 – 24) for refrigerating construction. With reference to the Standard Specifications for Brass Pipe, Standard Sizes (B 43 – 24), the question is still under discussion of the proper formula for test pressures in view of the fact that the outside diameter is specified in the test pressure formulas appearing in the Society's specifications for steel pipe and tubes, whereas the inside diameter is specified in the specifications of the Federal Specifications Board. A review of the Standard Specifications for Cartridge Brass (B 19 – 19) and for Cartridge Brass Disks (B 20 – 19) is being made by a sub-sub-committee with a view to reconciling them with the corresponding ones of the Federal Specifications Board.

The limits on the requirements for tin and copper in the Standard Specifications for Naval Brass Rods for Structural Purposes (B 21 – 19) are under discussion, and while it is generally agreed that a requirement for copper of 60 per cent ±1.25 per cent and a requirement for tin of 0.5 to 1 per cent is desired with the recommendation that the lower content be used when forging properties are particularly desired and the higher copper content when machining properties are in question, it is believed that the sub-committee should give the matter further consideration before offering a revision of the present specifications. The sub-committee has jurisdiction over the Standard Specifications for High Sheet Brass (B 36 – 21) and accordingly certain additions to its membership have been made in consequence of which the sub-committee has now been made a sectional committee functioning under the Rules of Procedure of the American Engineering Standards Committee. It is therefore in a position to act upon the changes in the tolerances in the standard specifications proposed in 1925 as a revision of the Tentative American Standard for High Sheet Brass.

The sub-committee is attempting to work out with the Federal Specifications Board such changes as are necessary to bring the present Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 - 24) into agreement with those of the Federal Specifications Board. The subject of measurement of the outside diameter of condenser tubes by go and no-go gages is under discussion. This has been referred to a sub-sub-committee upon which the prime movers are represented.

It is recommended that the following be continued as tentative for another year:

Tentative Specifications for Muntz Metal Condenser Tube Plates (B 57 - 24 T);

The tentative revisions of tolerances in the Standard Specifications for Seamless Admiralty Condenser Tubes and Ferrule Stock (B 44 - 24);

The tentative revisions of tolerances in the Standard Specifications for High Sheet Brass (B 36 - 21);

The tentative revision in method of measuring yield point in the Standard Specifications for Naval Brass Rods for Structural Purposes (B 21 - 19).

SUB-COMMITTEE III ON SAND-CAST METALS AND ALLOYS

Four new specifications are submitted as appended hereto[1] with the recommendation that they be accepted for publication as tentative:

Proposed Tentative Specifications for Aluminum Bronze Castings;

Proposed Tentative Specifications for Sand Castings of the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent;

Proposed Tentative Specifications for Steam or Valve Bronze Sand Castings;

Proposed Tentative Specifications for Composition Brass or Ounce Metal Sand Castings.

The present Tentative Specifications for Manganese-Bronze Ingots for Sand Castings (B 7 - 24 T), and for Manganese-Bronze Sand Castings (B 54 - 24 T) are recommended to be continued as tentative for another year.

SUB-COMMITTEE IV ON WHITE METALS—TIN, LEAD AND ZINC

The study of white metals for bearings, etc., is being continued. Professor MacFarland of Pennsylvania State College is carrying out some research work on drossing and brittleness of various compositions of white metals. It is hoped that the U. S. Bureau of Standards may take up some wear tests on alloys of the same composition.

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[1] See pp. 697–711.—ED.

A paper by Mr. E. R. Darby of the Chicago Bearing Metal Co. on "Fluidity Tests of White-Metal Bearing Alloys," appears as Appendix III to this report.

The Tentative Specifications for White Metal Bearing Alloys (known commercially as "Babbitt Metal") (B 23 - 18 T)[1] are recommended for advancement to standard.

SUB-COMMITTEE VI ON NON-FERROUS ALLOYS FOR RAILROAD EQUIPMENT

A meeting of the manufacturers of bearing metals and of the committee of the American Railway Association was held in Pittsburgh, following which the Committee of the A.R.A. drew up new tentative specifications which will be presented at their meeting in June. If these are adopted, Sub-Committee VI will consider them for publication as tentative standards.

SUB-COMMITTEE VII ON METHODS OF CHEMICAL ANALYSIS

Revisions are recommended in the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 25 T)[2] consisting in the deletion of the methods of determination of aluminum and aluminum oxide appearing on pages 610 and 611 of Part I of the Proceedings for 1925 and in the modification of the method of determination of iron appearing on page 593 of the Proceedings. This modification consists of the following:

Under "Method," substitute for the second and third paragraph the following:

"Dissolve the sulfide precipitate through the filter paper with warm dilute H_2SO_4 (1:10), washing the paper thoroughly, alternately with hot distilled water and with 5-per-cent H_2SO_4, using in all about 100 cc. Boil until H_2S is expelled and add, while hot, a few drops of concentrated solution of $KMnO_4$ until a distinct pink color persists. Boil again, cool and pass the solution through the reductor. Wash the beaker and reductor with 150 cc. of dilute H_2SO_4 for reductor and then with 100 cc. of distilled water. Titrate with standard $KMnO_4$ solution."

Also add the following under "Notes" at the top of page 594:

"In adding the few drops of concentrated solution of $KMnO_4$ for oxidation, only a very slight excess is used. There may be precipitated a very slight amount of manganese oxide but this can be disregarded in passing the solution through the reductor."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 538 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 155.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 590 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 171.

Revisions are proposed in the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings (B 45 – 23)[1] and of Bronze Bearing Metal (B 46 – 23).[1] These consist in the addition to both standards of two methods for the determination of aluminum in small quantities, one method for accurate work and one method for control work. These are recommended for publication as tentative as given below:

METHOD FOR THE DETERMINATION OF ALUMINUM IN SMALL QUANTITIES

A. GENERAL METHOD FOR ACCURATE WORK

SOLUTIONS REQUIRED

"Electrolytic Solution."—Mix 300 cc. of HNO_3 (sp. gr. 1.42), 1700 cc. of distilled water, and 500 cc. of H_2SO_4 (sp. gr. 1.84).

Acidified H_2S Water for Washing.—Dilute 10 cc. of HCl (sp. gr. 1.19) with 1000 cc. of distilled water and saturate with H_2S.

Phenylhydrazine Solution for Washing.—Add saturated SO_2 water to a few cubic centimeters of phenylhydrazine until the crystallin sulfite first formed is redissolved, and then add phenylhydrazine, drop by drop, with vigorous agitation, until the odor of SO_2 is no longer perceptible; dilute 5 to 10 cc. of this solution with 100 cc. of hot water and allow to remain at the boiling point for a few minutes so as to get rid of the excess SO_2.

NH_4Cl Solution for Washing (2-per-cent).—Mix 30 cc. of HCl (sp. gr. 1.19) with 200 cc. of distilled water, add methyl red, neutralize with NH_4OH until the solution changes to a distinct yellow, and then dilute to 1000 cc. with water.

METHOD

Dissolve 1 g. of brass or bronze in 35 cc. of "electrolytic solution," dilute with 100 cc. of distilled water and remove copper by electrolysis. Evaporate the electrolyte to fumes of SO_3. (If much tin is present, boil the sulfuric acid solution vigorously for a few minutes.) Cool and dilute with 100 cc. of water. Filter off $PbSO_4$ and any tin which may be precipitated at this point, washing with hot water. Dilute the filtrate to at least 200 cc.

Pass H_2S into the filtrate for 30 minutes. This will precipitate any copper, lead, tin, arsenic, or antimony which may be present. Allow the sulfides to settle, and filter, washing with acidified H_2S water. Boil the filtrate to one-half volume to expel H_2S, add 3 cc. HNO_3 (sp. gr. 1.42) and boil for a few minutes to oxidize iron.

Precipitate iron and aluminum according to the following:[2] Add 10 cc. of HCl (sp. gr. 1.19) and just neutralize with NH_4OH, using methyl red as an indicator. Boil for two minutes and filter, washing with hot 2-per-cent NH_4Cl. Dissolve the precipitate from the paper with *boiling hot* HCl (1:1) and wash alternately with hot water and HCl (1:1) into the beaker in which the precipitation was made. Reprecipitate the iron and aluminum following the same procedure as before.

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[1] 1924 Book of A.S.T.M. Standards.

[2] Blum: U. S. Bureau of Standards *Scientific Paper, No. 286*, 1916; *Journal*, American Chemical Society, Vol. 38, p. 1282 (1916).

Dissolve the precipitate again with hot HCl (1:1), dilute to 100 cc. with water, make just ammoniacal, then only acid enough to hold iron in solution. Add sufficient saturated solution of ammonium bisulfite to reduce the iron (5 to 20 drops). Add a few drops of methyl orange, quickly bring to neutrality with NH_4OH, and then add 6 to 7 drops of HCl (1:1) in excess. Finally add from 1 to 3 cc. of phenylhydrazine and stir until the precipitate becomes flaky. The supernatant liquid should be plainly acid to litmus and the precipitate may be colored owing to organic matter. Filter and wash with phenylhydrazine wash solution. Ignite in a weighed platinum crucible, finishing with the blast for 5 minutes. Weigh as Al_2O_3. The weighing should be made rapidly and with the crucible covered as Al_2O_3 is somewhat hygroscopic.

NOTES

1. For small amounts of aluminum, a 5-g. sample should be used. In this case dissolve in 60 cc. of "assay solution" of the following proportions:

7 volumes HNO_3 (sp. gr. 1.42);
10 volumes H_2SO_4 (sp. gr. 1.84);
25 volumes H_2O.

2. When phosphorus is present the final precipitate will be $Al_2O_3 + P_2O_5$. In this case it is necessary to fuse the residue with Na_2CO_3, dissolve with hot water, acidify with HNO_3, and determine phosphorus according to the Alkalimetric Method of the Standard Methods of Chemical Analysis of Bronze Bearing Metal (Serial Designation: B 46).[1] The phosphorus is calculated to P_2O_5 and subtracted.

3. For accurate work the Al_2O_3 residue is treated with HF and H_2SO_4 for the removal of possible SiO_2.

4. Ammonium bisulfite solution may be prepared by saturating cold NH_4OH (1:1) with SO_2 until yellow.

5. This method is especially satisfactory for small amounts of aluminum in brass or bronze since no reagents are used which may contaminate the precipitate with aluminum, iron or silica. A precipitate with phenylhydrazine gives positive indication of the presence of aluminum.

B. RAPID METHOD FOR CONTROL WORK

SOLUTIONS REQUIRED

Sodium Hydroxide Solution (2.5-per-cent).—Dissolve 25 g. of NaOH (free from aluminum) in water and dilute to 1000 cc.

Sodium Sulfide Solution.—Dissolve 150 g. of NaOH (free from aluminum) in 1000 cc. of water, saturate 500 cc. of this solution with hydrogen sulfide, and mix with the remaining 500 cc. of solution.

Dilute Hydrochloric Acid (1:3).—Mix 200 cc. of HCl (sp. gr. 1.19) with 600 cc. of water.

Acidified Hydrogen Sulfide Water.—Dilute 10 cc. of HCl (sp. gr. 1.19) with 1000 cc. of water and saturate the solution with hydrogen sulfide.

Ammonium Chloride Solution (2-per-cent).—Mix 30 cc. of HCl (sp. gr. 1.19) with 200 cc. of water, add methyl red, neutralize with ammonia until the solution changes to a distinct yellow, and then dilute to 1000 cc. with water.

METHOD

Dissolve 2 g. of the sample in 20 cc. of HCl (sp. gr. 1.19) and 5 cc. of HNO_2 (sp. gr. 1.42). Boil the solution to expel chlorine and dilute with 50 cc. of water. Nearly neutralize the cold solution with sodium hydroxide solution (2.5-per-cent, or stronger if much free acid is present), and pour it slowly and with constant shaking into a 500-cc. volumetric flask containing 100 cc. of sodium sulfide solution. Dilute to the mark with sodium hydroxide solution (2.5-per-cent) and mix thoroughly. Filter on a large, dry, No. 42 Whatman filter paper (or its equivalent) and keep the paper well filled with the solution lest iron be oxidized and dissolved. Reject the first 20 to 25 cc., and catch exactly 250 cc. which will represent 1 g. of sample. In routine analyses of material containing not more than 1 per cent of aluminum, the aliquot portion can be gathered in a 250-cc. graduate.

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[1] 1924 Book of A.S.T.M. Standards

Transfer the aliquot portion to a 600-cc. beaker, neutralize the solution with dilute HCl (1:3), and finally add 25 cc. in excess. Digest at 40 to 60° C. for 1 hour, filter, and wash the paper and precipitate with acidified hydrogen sulfide water.

Boil the filtrate and washings to expel hydrogen sulfide, add a few drops of methyl red indicator, and then dilute ammonia (1:2) until the solution is just distinctly yellow. Boil for 1 to 2 minutes and filter at once through a small filter. Wash the beaker, paper, and precipitate two or three times with hot ammonium chloride solution (2-per-cent) and discard the filtrate. Dissolve the precipitate in 20 cc. of hot dilute HCl (1:3), wash the filter thoroughly with small portions of hot water, and reserve it for the second filtration. Dilute the filtrate to 50 cc., add methyl red, and precipitate with dilute ammonia (1:2) as before. Filter, wash with hot ammonium chloride solution (2-per-cent), ignite, and weigh.

The ignited residue is prone to carry silica and must be purified before weighing as follows: Add one or two drops of water, one drop of diluted H_2SO_4, and 1 to 5 cc. of HF. Evaporate to dryness, increase the heat slowly, and finally heat with a blast lamp or its equivalent. Weigh as Al_2O_3. The weight of Al_2O_3 corrected for the blank and multiplied by 52.94 gives the percentage of aluminum.

NOTES

The first aluminum hydroxide precipitate will carry down some sodium chloride and much of any silica that was dissolved in the sodium hydroxide solution; hence it is not safe to omit the second precipitation and the hydrofluoric acid treatment. There is no attack on the glassware during the short contact with the weak, cool, alkaline solution. It is, of course, preferable that the sodium hydroxide be free from aluminum. The most satisfactory test for it lies in running an analysis with non-ferrous alloys containing no aluminum. Direct test, by acidification followed by precipitation with ammonia, is sufficient if no precipitate is obtained, but is of doubtful value in case one appears, for it may contain other elements, such as iron, which do not affect the results.

If phosphorus is known to be present, the method should be followed through the first addition of ammonia. If aluminum is indicated, re-acidify the solution with HCl, add macerated paper, two drops of methyl orange, and 10 cc. of a solution of diammonium phosphate (10-per-cent.) Render the solution just ammoniacal, then just restore the pink color with dilute HCl (1:3), heat to boiling, and add 30 cc. of a solution of ammonium acetate (25-per-cent). Boil for 5 minutes, filter on an 11-cm. No. 42 Whatman or similar filter paper, and wash with hot ammonium nitrate solution (5-per-cent) until 5 cc. of the washings no longer give a test for chlorides with acidified silver nitrate. Ignite in platinum or porcelain, heat at approximately 1100° C. for 10 minutes, and weigh as $AlPO_4$. This method is not strictly accurate on account of the uncertain composition of the phosphate, but is sufficiently accurate for all but the most painstaking analyses.

SUB-COMMITTEE VIII ON LIGHT METALS AND ALLOYS

New Tentative Specifications for Aluminum-Base Sand-Casting Alloys in Ingot Form have been prepared as appended hereto.[1] These are recommended for publication as tentative.

The Tentative Specifications for Aluminum for Use in the Manufacture of Iron and Steel (B 37 – 20 T)[2] are recommended for advancement to standard.

The question of the claim clause, particularly in the Tentative Specifications for Aluminum Ingots for Remelting (B 24 – 25 T),[3] has been considered with a view to wording it in such a way that it definitely suggests effort on the part of producer and buyer to reconcile differences in chemical analysis before resorting to an umpire. It is recommended that Section 9 of these specifications be revised as follows:

Section 9.—Change to read as follows by the addition of the italicized words:

> "Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant *to endeavor to reconcile the differences between the two laboratories and in the event of failure to reach an understanding,* to resample the shipment, as specified in Section 3. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final."

It is recommended that the specifications as revised be continued as tentative.

The Tentative Specifications for Aluminum Sheet (B 25 – 19 T)[4] have been completely revised and are appended hereto in their revised form.[5] It is recommended that the revised specifications be accepted for publication as tentative.

A revision in the Tentative Specifications for Aluminum Base Alloy Sand Castings (B 26 – 25 T)[6] is recommended which will permit a taper in the reduced section of the test specimen from the fillets to the middle of the reduced section of not to exceed 0.01 in. The specifications, as revised, are to be continued as tentative.

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[1] See p. 691.—Ed.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 586 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 165.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 585 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 160.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 546 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 162.

[5] See p. 715.—Ed.

[6] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 574 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 128.

The Properties of High-Strength Aluminum Casting Alloys are given in Appendix II to this report.

SUB-COMMITTEE IX ON NOMENCLATURE OF METALS AND ALLOYS

Due to his permanent location on the West Coast, Mr. E. L. Lasier has found it necessary to resign as chairman of the sub-committee and Mr. E. E. Thum has been appointed in his stead.

SUB-COMMITTEE X ON METHODS OF TESTING

Mr. H. A. Anderson was appointed chairman of the sub-committee in place of Mr. P. D. Merica and to serve as liaison member on Committee E-1 on Methods of Testing.

SUB-COMMITTEE XI ON LEAD PIPE

The work of this sub-committee has been completed and on the recommendation of its chairman, Mr. W. A. Cowan, it was discharged with appreciation of the service it had rendered.

SUB-COMMITTEE XII ON METALLIC FLUXES AND DEOXIDIZERS

The sub-committee reports progress and its chairman, Mr. P. E. McKinney, asks for suggestions as to any additional specifications on non-ferrous deoxidizing alloys or fluxes which would be desirable. The present Tentative Specifications for Phosphor Tin (B 51 – 24 T), for Phosphor Copper (B 52 – 24 T), and for Silicon Copper (B 53 – 24 T) are to be continued as tentative for another year.

SUB-COMMITTEE XIII ON SHEET AND STRIP ZINC

This new sub-committee has been organized under the chairmanship of Mr. G. C. Stone and has begun the preparation of specifications, for which there is an undoubted need. A Proposed Outline for Specifications for Rolled Zinc appears as information as Appendix I to this report.

SUB-COMMITTEE XIV ON SILVER AND GOLD SOLDERS

The subject of gold and silver solders has been brought to the attention of Committee B-2 more than once, as well as that of hard and spelter solder. After discussion it has been decided that hard solders could be handled by Sub-Committee II and that a new sub-committee should be formed to take care of the precious metal solders. Such a sub-committee is in the process of formation.

Attention is called to the fact that the pamphlet entitled "A List of Alloys" published in 1922, sponsored by Committee B-2 will probably be revised in the near future and members of the Society are earnestly requested to send in to the chairman corrections or additions to bring this list up to date. Records of physical and chemical properties will also be very welcome.

The analysis of the letter ballot of the committee is as follows:

Item	Affirmative	Negative	Not Voting
I. PROPOSED REVISION IN STANDARDS			
1. Methods of Chemical Analysis of Brass Ingots (B 45 - 23)	41	0	73
2. Methods of Chemical Analysis of Bronze Bearing Metals (B 46 - 23)	42	0	72
II. PROPOSED REVISION IN TENTATIVE STANDARDS			
3. Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (B 40 - 25 T)	40	0	74
4. Specifications for Aluminum Ingots (B 24 - 25 T)	38	1	75
5. Specifications for Aluminum Sheet (B 25 - 19 T)	38	1	75
6. Specifications for Aluminum-Base Alloy Sand Castings (B 26 - 25 T)	39	1	74
III. PROPOSED NEW TENTATIVE STANDARDS			
7. Specifications for Aluminum Bronze Castings	40	0	74
8. Specifications for the Alloy: Copper 88 per cent, Tin 8 per cent, Zinc 4 per cent	41	0	73
9. Specifications for Steam or Valve Bronze	40	1	73
10. Specifications for Composition Brass or Ounce Metal	41	0	73
11. Specifications for Aluminum-Base Sand-Casting Alloy Ingots	37	1	76
IV. TENTATIVE STANDARDS ADVANCED TO STANDARD			
12. Specifications for White Metal Bearing Alloy (B 23 - 18 T)	40	1	73
13. Specifications for Aluminum for Use in the Manufacture of Iron and Steel (B 37 - 20 T)	34	1	79

This report has been submitted to letter ballot of the committee, which consists of 114 members, of whom 42 have voted affirmatively, none negatively, and 72 have refrained from voting.

Respectfully submitted on behalf of the committee,

WILLIAM CAMPBELL,
Chairman.

P. D. MERICA,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Methods of Chemical Analysis of Brass Ingots and Sand Castings; and of Bronze Bearing Metal were accepted for publication as tentative and appear on pages 1120 to 1123.

The proposed revisions of the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys; and of the Tentative Specifications for Aluminum Ingots for Remelting; for Aluminum Sheet; and for Aluminum-Base Alloy Sand Castings were accepted. The tentative standards as thus revised appear on pages 718, 712, 715 and 693.

The Tentative Specifications for White Metal Bearing Alloys (known commercially as "Babbitt Metal"); and for Aluminum for Use in the Manufacture of Iron and Steel were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed Tentative Specifications for Aluminum Bronze Castings; for Sand Castings of the Alloy: Copper 88 per cent, Tin 8 per cent; Zinc 4 per cent; for Steam or Valve Bronze Sand Castings; for Composition Brass or Ounce Metal Sand Castings; and for Aluminum-Base Sand-Casting Alloys in Ingot Form were accepted for publication as tentative and appear on pages 697 to 711, and page 691.

APPENDIX I

A PROPOSED OUTLINE FOR SPECIFICATIONS
FOR
ROLLED ZINC

1. These specifications cover commercial rolled zinc. It should be understood that they are general. Any closer tolerances required shall be a matter of adjustment between buyer and seller at the time of purchase.

I. GRADES

2. Rolled zinc shall be divided into the following grades:
Grade A.—Strip or ribbon zinc and sheets cut from strip zinc.
Grade B.—Sheet zinc.
Grade C.—Boiler plate, name plates, tags, etc.

II. MANUFACTURE

3. (*a*) Rolled zinc Grade A is rolled from a single bar in one continuous direction.

(*b*) Rolled zinc Grade B is rolled by the pack rolling method.

(*c*) Rolled zinc Grade C can be rolled either from a single bar, or by the pack rolling method.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS

4. The thickness of plates, sheets and strips shall be stated in decimals of an inch.

Grade A

5. Permissible variation in thickness of strips and sheets cut from strip zinc shall be as given below:

PERMISSIBLE VARIATIONS, PLUS OR MINUS, IN STRIP ZINC, IN.

AMERICAN ZINC GAGE	THICKNESS, IN.	0 TO 6 IN. IN WIDTH, INCLUSIVE	OVER 6 TO 9 IN. IN WIDTH, INCLUSIVE	OVER 9 TO 14 IN. IN WIDTH, INCLUSIVE	OVER 14 TO 20 IN. IN WIDTH, INCLUSIVE
3	0.006	0.0009	0.0010	0.0011	0.0012
4	0.008	0.0010	0.0011	0.0012	0.0013
5	0.010	0.0011	0.0012	0.0013	0.0014
6	0.012	0.0011	0.0012	0.0013	0.0014
7	0.014	0.0013	0.0014	0.0015	0.0016
8	0.016	0.0014	0.0015	0.0016	0.0017
9	0.018	0.0015	0.0016	0.0017	0.0018
10	0.020	0.0016	0.0017	0.0018	0.0019
11	0.024	0.0018	0.0019	0.0020	0.0021
12	0.028	0.0019	0.0020	0.0021	0.0022

American Zinc Gage	Thickness, in.	0 to 6 in. in Width, inclusive	Over 6 to 9 in. in Width, inclusive	Over 9 to 14 in. in Width, inclusive	Over 14 to 20 in. in Width, inclusive
13	0.032	0.0020	0.0021	0.0023	0.0024
14	0.036	0.0021	0.0023	0.0025	0.0026
15	0.040	0.0022	0.0024	0.0026	0.0028
16	0.045	0.0023	0.0025	0.0027	0.0029
17	0.050	0.0024	0.0026	0.0028	0.0030
18	0.055	0.0025	0.0027	0.0029	0.0031
19	0.060	0.0026	0.0028	0.0030	0.0032
20	0.070	0.0027	0.0029	0.0031	0.0033
21	0.080	0.0028	0.0030	0.0032	0.0034
22	0.090	0.0029	0.0031	0.0033	0.0035
23	0.100	0.0030	0.0032	0.0034	0.0036
24	0.125	0.0032	0.0033	0.0035	0.0037

Note.—Thicknesses of metal falling between the gages shall take the tolerances of the nearest gage.

Grade B

6. Permissible variation in thickness of sheets shall be as given below:

PERMISSIBLE VARIATIONS IN THICKNESS OF SHEETS.

American Zinc Gage	Thickness, in.	Percentage Variation by Weight
3	0.006	±16
4	0.008	±13
5	0.010	±10
6	0.012	± 9
7	0.014	± 8
8	0.016	± 6
Over 8	.....	± 6

Note.—The gage tolerance on sheet zinc is a percentage plus or minus by weight based on the theoretical weight of any gage or size of sheet for each unit of 500 lb., zinc assumed to weigh 0.2596 lb. per cu. in. No individual sheet shall weigh more than the theoretical weight of a sheet of the gage next above nor less than the theoretical weight of a sheet of the gage next below.

Grade C

7. The gage tolerances for Grade C zinc shall be the same as either those for Grades A or for B, depending on whether or not the material is cut from a strip or a sheet.

8. (*a*) The permissible variation in width of sheets and strips, Grades A, B and C, up to 0.100 in. in thickness shall be as follows:

Width, in.	Permissible Variation, in. Plus	Permissible Variation, in. Minus
2 and under	0.010	0
Over 2 to 5, inclusive	0.025	0
Over 5 to 14, inclusive	0.050	0
Over 14	0.125	0

(*b*) The permissible variation in width from 0.100 to 0.250 in. in thickness shall be plus or minus $\frac{1}{32}$ in., and from 0.250 to 0.500 the permissible variation shall be ⅛ in. plus or minus, and on material ½ in. and over in thickness a variation of plus ¼ in. shall be permitted.

9. (*a*) Sheets, strips and plates may be ordered to exact lengths up to 12 ft., in which case a variation of plus ¼ in. in length shall be permitted.

(*b*) When plates, sheets and strips are ordered in stock lengths, the pieces shall be cut to the nominal or stock length as a maximum. The shortest acceptable lengths, the maximum permissible percentage by weight of short lengths and the required percentage by weight of stock lengths in any one shipment shall be as given below:

PERMISSIBLE VARIATIONS IN LENGTH OF PLATES, SHEETS, AND STRIPS UP TO 20 IN. IN WIDTH.

NOMINAL OR STOCK LENGTH, FT.	REQUIRED PERCENTAGE BY WEIGHT OF STOCK LENGTHS	MAXIMUM PERMISSIBLE PERCENTAGE BY WEIGHT OF SHORT LENGTHS				
		8 TO 10 FT.	6 TO 8 FT.	4 TO 6 FT.	2 TO 4 FT.	UNDER 2 FT.
10	60	40	30	20	10	0
8	70	..	30	20	10	0
6	80	..	..	20	10	0

10. When rolled zinc Grade A is supplied in coils, it shall be consistent with good commercial practice, and in no case shall a coil consist of more than 4 pieces. No piece shall be less than 10 ft. long.

11. Grade A strips and sheets in lengths over 10 ft. shall not exhibit sidewise bend or curvature in excess of 1 in. in any length of 10 ft.

IV. METHODS OF INSPECTION

12. *Test for Sidewise Bend or Curvature.*—The coil shall be supported on a reel at one end of a table and the strip drawn along the table in a straight line. The edges of the strip shall not deviate more than one inch from either side of a straight line in any length of 10 ft.

13. *Gaging Grade A Zinc.*—The zinc shall be gaged with a micrometer caliper which has previously been checked with precision blocks. No two measurements along the length of the coil shall be made within 12 in. of each other, nor shall measurements in any one line across the width of the coil be used as a basis for rejection.

V. PACKING AND MARKING

14. (*a*) All material shall be properly separated according to size when loaded for shipment. In the case of shipments of plates, sheets and strips packed in boxes or crates, the containers shall be sufficiently strong to protect them from injury and loss during shipment.

(*b*) Bulk shipments shall be properly braced in the car.

(*c*) Each bundle, box or crate shall be legibly marked with the grade letter, dimensions and gross, tare and net weight.

NOTES

It is the aim of Sub-Committee XIII on Strip Zinc of Committee B-2 to draw up a complete standard for rolled zinc which will include in addition to dimensional tolerances the physical characteristics.

The sub-committee is considering the proposal of two tests to determine these physical characteristics: namely,

1. The dynamic ductility test;
2. The temper test.

These two tests have been found by certain of the producers of rolled zinc to be the most reliable tests yet devised for determining the quality of rolled zinc.

In order to invite discussion the following short description is given, and complete details of these tests and also blue prints of the equipment can be obtained from Mr. John L. Christie, Secretary, Sub-Committee XIII, Committee B-2, Bridgeport Brass Co., Bridgeport, Conn.

1. *Dynamic Ductility Test*

In the case of zinc, the speed of testing materially influences the values obtained in the well known Olsen cupping test. A dynamic or rapid ductility testing apparatus has been designed which gives ductility values for rolled zinc more nearly comparable with the results obtained from actual drawing and forming operations in the shop and is adapted for testing material under 0.050 in. in thickness.

The apparatus is attached to an ordinary inclinable power press. A spherical-headed plunger, $\frac{7}{8}$ in. in diameter, screws into a holder fastened to the slide of the press. This plunger passes down through the circular opening in the bolster plate fastened to the bed of the press. The die, 1 in. in diameter, slides in a cylindrical guide fastened to the bed of the press and is moved up or down by opening and closing the toggle joint. The die is thus made to serve the purpose of a clamp holding the material to be tested tightly between its face and the bottom of the bolster plate. The plunger can be screwed in or out of the holder to regulate the depth of cup to be made, the exact depth in thousandths of an inch being given by the scale and micrometer wheel attached to the plunger. The test piece is $3\frac{1}{2}$ by 12 or 14 in. A series of cups of various depths are made until the depth of cup is obtained at which local reduction of area or necking occurs. This depth reported in thousandths of an inch is taken as the dynamic ductility. The press is operated at 90 r. p. m., and should be equipped with a tripping arrangement so that the plunger makes only one stroke for every cup.

The determination of end point in this test is one where careful examination on the part of the operator is required. The most easily reproducible results are obtained if the point of failure is taken as that point at which the first sign of the necking down, which precedes actual cracking of the cup, occurs. If the point of actual cracking were taken as the failure point, the results would be more erratic.

2. *Temper Test*

The temper of strip or sheet zinc is indicated by the temper machine. This machine is essentially a slotted mandrel placed in a perpendicular position and supported by a suitable frame. The mandrel is driven by a motor at a constant speed and a shoe or contact arm presses at right angles against the mandrel. It is adapted for determining the temper of material under 0.035 in. in thickness. A test specimen, $1\frac{1}{2}$ by $4\frac{31}{32}$ in., is cut from the sheet or strip and clamped in the mandrel, the length of the specimen extending outward from the mandrel being equal to half the circumference of the mandrel. The contact arm is forced against the mandrel by means of a strong spring. The function of this contact arm is to wrap the test specimen tightly against the face of the mandrel as the latter is rotated slowly in a counter-clockwise direction. The rotation is continued until the entire length of test specimen has passed under the contact arm, when the elasticity of the metal causes it to fly out from the mandrel.

If the strip were perfectly elastic it would spring out straight and the end would be on the line marked 100 on the brass scale attached to the bed of the machine. If the strip had no elasticity it would not spring at all, and when the end of the strip cleared the plunger it would then lie at the point marked zero on the brass scale which is 180 deg. from the point marked 100. The scale is divided into 100 equal divisions between these two positions, and the position to which the end of the specimen springs is read on this scale and called the temper in per cent.

Per cent temper varies with the direction of grain in the specimen. It is, therefore, necessary that all specimens be cut with the grain running parallel to the length of the specimen. In the case of metal which has been coiled, the specimen will have initial set and two check specimens should always be tested, inserting one in the machine so that the bending occurs in the same direction as the original coiling and inserting the other specimen so that it is bent in a direction opposite the original coiling. The average of the two results should be reported as the temper.

Since this test, like all other tests on zinc, is affected by the rate of deformation, the temper machine is equipped with a motor drive connected through an automatic clutch which releases as soon as the specimen has passed beyond the plunger. The mandrel is then adjusted by hand to the proper position for reading as indicated by a small pointer and mark on the mandrel shaft and the bearing in which it turns.

APPENDIX II

THE PROPERTIES OF HIGH-STRENGTH ALUMINUM CASTING ALLOYS

The success which has been realized in producing high-strength wrought aluminum alloys has been the incentive for a large amount of research work having as its object the production of casting alloys showing a similar improvement in mechanical properties over those which are possessed by the commonly used commercial alloys. As a result, there have been developed and placed upon the market at least four alloys which, to a greater or lesser degree, fulfill the requirements of the desired alloy. While these alloys are in commercial production, their recent introduction has made it appear desirable to present a general discussion of their properties rather than to attempt to cover them with formal specifications. Three of the alloys to be considered are proprietary, being covered by United States and foreign patents.

Two of the alloys depend upon heat treatment to produce their exceptional properties, one is given a special fluxing or "modification" treatment prior to casting, while in the fourth, the properties depend entirely upon the composition used.

The alloy which is probably used most extensively is designated "No. 195" by its manufacturer. This alloy has the following composition:

Copper	4.0 – 5.0	per cent
Silicon, not over	1.2	"
Iron, not over	1.2	"
Magnesium, not over	0.35	"
Zinc, not over	0.35	"
Total of constituents other than copper and aluminum, not over	2.5	"
Aluminum	Remainder.	

This alloy is guaranteed to have a minimum tensile strength of 28,000 lb. per sq. in. and a minimum elongation in 2 in. of 6.0 per cent. The tension test data from several thousand routine tests show a variation in strength from 28,000 to 38,000 lb. per sq. in. and occasionally even higher, with an average of 31,000 lb. per. sq. in. while the elongation in 2 in. varies from 6.0 to 12.0 per cent with an average value of 8.0 per cent. One of the principal advantages of this alloy is its high yield point; the value for this property shortly after casting is about 14,000 to 18,000 lb. per sq. in. On standing at ordinary temperatures, the yield point increases until a value of about 20,000 to 25,000 lb. per sq. in. is reached. This change is accompanied by a much smaller increase in tensile strength and a slight decrease in the elongation.

This alloy has been poured into large and intricate castings which have been subsequently heat treated with entire success. To cite a specific example, a crankcase weighing over 650 lb. for use in a six-cylinder fire-engine motor is in regular production from this alloy. While it may be necessary to make some alteration in patterns that have been designed for use with the common aluminum casting alloys before they can be used successfully with No. 195 alloy, these changes are not serious and will consist for the most part in increasing the radius of fillets so as to give less abrupt changes in cross-section of the metal. Experience indicates that misgivings which were expressed concerning the applicability of heat treatment processes to aluminum castings were not well founded, or at least that the difficulties have been largely overcome.

Another alloy which has been given a large amount of attention in the scientific and technical press is the so-called "Y" alloy which was developed at the National Physical Laboratory in England. One of the chief advantages claimed for this alloy is its property of retaining a relatively higher percentage of its room temperature tensile strength when tested at elevated temperatures than is the case with the common casting alloys. This alloy also responds to heat treatment processes with a marked increase in tensile strength of the material as cast but with no substantial improvement in the elongation. This alloy is not used extensively at the present time in this country as a sand casting alloy, and production data are too limited to establish commercial limits for tensile properties of sand castings. The composition limits usually given for this alloy are as follows:

Copper	3.75 – 4.50	per cent
Nickel	1.75 – 2.25	"
Magnesium	1.25 – 1.50	"
Silicon, not over	0.5	"
Iron, not over	0.75	"
Aluminum	Remainder	

The tensile strength of this alloy in the heat-treated temper probably varies over a range comparable with that given above for No. 195 alloy while the elongation varies from 0 to 2.0 per cent.

The modified silicon alloy sold in this country under the designations "Alpax" or "No. 47 alloy" and in Europe as "Alpax" or "Silumin" has properties which place it in the class of the special casting alloys of aluminum. The composition of this alloy is as follows:

Silicon	12.0 – 13.0 per cent
Iron, not over	0.8 "
Copper, not over	0.15 "
Manganese, not over	0.25 "
Zinc, not over	0.2 "
Aluminum	Remainder

If this alloy be cast in a sand mold in the same manner as other casting alloys, the resulting casting will show a coarse crystallin fracture and will have only moderate strength and little ductility. If, however, the molten metal be treated with a special flux or with metallic sodium before pouring, a broken section will show a very fine silky fracture and both strength and elongation will be materially improved. These special treatments or modification processes are covered by patents.

Sand-cast test specimens poured from this alloy properly modified will show a minimum tensile strength of 24,000 lb. per sq. in. and a minimum elongation in 2 in. of 5 per cent. The production test data show a range of tensile strength from 24,000 to 31,000 lb. per sq. in. with an average for several hundred tests of 26,000 lb. per sq. in. The elongation in 2 in. varies from 5.0 to 15.0 per cent, the average being 7.6 per cent.

In favor of this alloy can be stated its good resistance to salt-water corrosion and the fact that intricate castings having both heavy and thin sections can be poured from it with comparative ease. It should be mentioned, however, that the ratio of yield point to tensile strength is not so high as in the common casting alloys of aluminum. In addition, some care is required in handling this metal in order to avoid excessive dross formation.

The proprietary alloy sold under the designation "No. 145" depending upon the composition alone to produce the desired properties and requiring no heat treatment or special foundry practice, has properties intermediate between those of the special heat-treated alloys and the common casting alloys. This alloy is manufactured in accordance with the following composition limits:

Zinc	10.0 – 11.0 per cent
Copper	2.0 – 3.0 "
Iron	1.0 – 1.5 "
Aluminum plus usual impurities	Remainder

It is guaranteed by the manufacturer to have a minimum tensile strength of 25,500 lb. per sq. in. and a minimum elongation in 2 in. of 3.0 per cent. Several hundred routine tests show tensile strengths varying between 25,500 to 34,000 lb. per sq. in., with an average value of 30,000 lb. per sq. in., and elongations in 2 in. varying from 3.0 to 7.0 per cent, the average being 4.2 per cent. This alloy is finding extensive application where the higher physical properties of No. 195 alloy are not essential and where the superior resistance to corrosion possessed by the modified silicon alloy is not required.

While this discussion may not be complete, it is believed to cover the more generally used commercial alloys of aluminum intended for the production of castings having higher mechanical properties than are obtained from the casting alloys which are in more common use.

APPENDIX III

FLUIDITY TESTS OF WHITE-METAL BEARING ALLOYS

By Ernest R. Darby[1]

A fluid substance is one that is not viscous, and "fluidity" may be considered that property which is the converse of "viscosity." As fluidity decreases it approaches the region of viscosity; and viscosity decreasing approaches the region of fluidity.

In measuring the viscosity of substances such as lubricating oils where specific gravities are comparatively constant, it is sufficient to measure the time of flow of a given volume at a standard head, as measured in height, through a standard orifice. With substances of widely varying specific gravities this method would bring into the reading the effect of different pressure heads even if the container be drained completely and the mean head taken as the pressure.

Table I.—Compositions of Alloys.

Alloy Grade No.	Tin, per cent	Antimony, per cent	Lead, per cent	Copper, per cent	Iron, maximum per cent	Arsenic, maximum per cent
1	91	4½	0.35[a]	4½	0.08	0.10
2	89	7½	0.35[a]	3½	0.08	0.10
3	83⅓	8⅓	0.35[a]	8⅓	0.08	0.10
4	75	12	10	3	0.08	0.15
5	65	15	18	2	0.08	0.15
6	20	15	63½	1½	0.08	0.15
7	10	15	75	0.50[a]	....	0.20
8	5	15	80	0.50[a]	....	0.20
9	5	10	85	0.50[a]	....	0.20
10	2	15	83	0.50[a]	....	0.20
11	..	15	85	0.50[a]	....	0.25
12	..	10	90	0.50[a]	....	0.25

[a] Maximum.

This difficulty is fundamental with another device used by the author in the measure of fluidity of lead-base lining metals at the plant of the Chicago Bearing Metal Co. By it the distance of flow into a small channel of an iron mold is the measure of the pouring temperature of the material tested. This when tried gave no directly comparable readings with metals of widely varying specific gravities.

By measuring the time of flow of a given weight of metal from a given gravity head through a constant orifice, the readings obtained would be directly comparable. They would compare the fluidity of weight units at a uniform pressure rather than volume units at varying pressures. This is in line with the universal conception of metal.

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[1] Chief Metallurgist, Chicago Bearing Metal Co., Chicago, Ill.

MATERIALS TESTED

At the request of Mr. G. H. Clamer, Chairman of Sub-Committee IV on White Metals, of Committee B-2 on Non-Ferrous Metals and Alloys, an attempt has been made to compare the fluidities of the white metals as specified by the A.S.T.M. Tentative Specifications for White Metal Bearing Alloys (Serial Designation B 23 - 18 T). Twelve alloys of the compositions given in Table I are designated.

These alloys were made up in 4000-g. lots from laboratory metals as nearly pure as possible. The analyses of these lots in no case varied from the desired percentages more than 0.1 per cent for the major ingredients and the allowable impurities such as iron and arsenic did not exceed 0.02 per cent each. Unfortunately the fluidity tests on but six of these alloys have been completed at the time of writing, but it is hoped that the remainder of the work, including the effect of impurities, may be reported at the 1927 annual meeting of the Society.

PRINCIPLE OF TEST

If a cylindrical vessel containing liquid metal has submerged in it a cylindrical tube extending above the metal with an orifice in the submerged end, the metal will rise in the tube to the level of the metal in the vessel. By increasing the pressure in the tube, the level of the liquid metal in it will be lowered and the level of the metal in the vessel will be raised. If upon the release of the pressure in the tube, the time required for the metal to again assume its normal level is noted, a measure of the flow of a certain weight of metal through a submerged orifice is obtained. This flow, however, would be affected by the surface radiation of heat and at low temperatures a considerable error would be introduced. To overcome this effect and secure a more positive end of flow, it is necessary to lower the end point considerably below the surface of the metal in the vessel. An electric contact placed in the tube at the desired point will accomplish this and will assure a constantly uniform temperature of the metal in the tube and in the vessel.

By reading the pressure with a manometer at the low and contact elevations (or high and low pressure points) and keeping these constant, together with the areas of the tube, orifice, and vessel, a constant weight of metal flowed will be measured regardless of its specific gravity. If the temperatures of the metals tested be varied and the times of flow from high to low pressures noted, the fluidity or rate of flow for any one metal at the desired temperature may be computed for a prescribed mean pressure by the following formulas:

$$R = \frac{W}{T} \dots\dots\dots\dots\dots\dots (1)$$

and

$$W = \frac{A}{A+a}(H-h)a, \dots\dots\dots\dots\dots (2)$$

in which R = rate of flow, in grams per second;
W = weight of metal flowing through orifice, in grams;
T = time of flow, in seconds;
H = initial or starting pressure head as read on manometer (centimeters);
h = low or contact pressure head as read on manometer (centimeters);

APPENDIX III

FLUIDITY TESTS OF WHITE-METAL BEARING ALLOYS

By Ernest R. Darby[1]

A fluid substance is one that is not viscous, and "fluidity" may be considered that property which is the converse of "viscosity." As fluidity decreases it approaches the region of viscosity; and viscosity decreasing approaches the region of fluidity.

In measuring the viscosity of substances such as lubricating oils where specific gravities are comparatively constant, it is sufficient to measure the time of flow of a given volume at a standard head, as measured in height, through a standard orifice. With substances of widely varying specific gravities this method would bring into the reading the effect of different pressure heads even if the container be drained completely and the mean head taken as the pressure.

This difficulty is fundamental with another device used by the author in the measure of fluidity of lead-base lining metals at the plant of the Chicago Bearing Metal Co. By it the distance of flow into a small channel of an iron mold is the measure of the pouring temperature of the material tested. This when tried gave no directly comparable readings with metals of widely varying specific gravities.

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Table I.—Compositions of Alloys.

Alloy Grade No.	Tin, per cent	Antimony, per cent	Lead, per cent	Copper, per cent	Iron, maximum per cent	Arsenic, maximum per cent
1	91	$4\frac{1}{2}$	0.35[a]	$4\frac{1}{2}$	0.08	0.10
2	89	$7\frac{1}{2}$	0.35[a]	$3\frac{1}{2}$	0.08	0.10
3	$83\frac{1}{3}$	$8\frac{1}{3}$	0.35[a]	$8\frac{1}{3}$	0.08	0.10
4	75	12	10	3	0.08	0.15
5	65	15	18	2	0.08	0.15
6	20	15	$63\frac{1}{2}$	$1\frac{1}{2}$	0.08	0.15
7	10	15	75	0.50[a]	....	0.20
8	5	15	80	0.50[a]	....	0.20
9	5	10	85	0.50[a]	....	0.20
10	2	15	83	0.50[a]	....	0.20
11	..	15	85	0.50[a]	....	0.25
12	..	10	90	0.50[a]	....	0.25

[a] Maximum.

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[1] Chief Metallurgist, Chicago Bearing Metal Co., Chicago, Ill.

MATERIALS TESTED

At the request of Mr. G. H. Clamer, Chairman of Sub-Committee IV on White Metals, of Committee B-2 on Non-Ferrous Metals and Alloys, an attempt has been made to compare the fluidities of the white metals as specified by the A.S.T.M. Tentative Specifications for White Metal Bearing Alloys (Serial Designation B 23 - 18 T). Twelve alloys of the compositions given in Table I are designated.

These alloys were made up in 4000-g. lots from laboratory metals as nearly pure as possible. The analyses of these lots in no case varied from the desired percentages more than 0.1 per cent for the major ingredients and the allowable impurities such as iron and arsenic did not exceed 0.02 per cent each. Unfortunately the fluidity tests on but six of these alloys have been completed at the time of writing, but it is hoped that the remainder of the work, including the effect of impurities, may be reported at the 1927 annual meeting of the Society.

PRINCIPLE OF TEST

If a cylindrical vessel containing liquid metal has submerged in it a cylindrical tube extending above the metal with an orifice in the submerged end, the metal will rise in the tube to the level of the metal in the vessel. By increasing the pressure in the tube, the level of the liquid metal in it will be lowered and the level of the metal in the vessel will be raised. If upon the release of the pressure in the tube, the time required for the metal to again assume its normal level is noted, a measure of the flow of a certain weight of metal through a submerged orifice is obtained. This flow, however, would be affected by the surface radiation of heat and at low temperatures a considerable error would be introduced. To overcome this effect and secure a more positive end of flow, it is necessary to lower the end point considerably below the surface of the metal in the vessel. An electric contact placed in the tube at the desired point will accomplish this and will assure a constantly uniform temperature of the metal in the tube and in the vessel.

By reading the pressure with a manometer at the low and contact elevations (or high and low pressure points) and keeping these constant, together with the areas of the tube, orifice, and vessel, a constant weight of metal flowed will be measured regardless of its specific gravity. If the temperatures of the metals tested be varied and the times of flow from high to low pressures noted, the fluidity or rate of flow for any one metal at the desired temperature may be computed for a prescribed mean pressure by the following formulas:

$$R = \frac{W}{T} \quad \ldots\ldots (1)$$

and

$$W = \frac{A}{A+a}(H-h)a, \quad \ldots\ldots (2)$$

in which R = rate of flow, in grams per second;
W = weight of metal flowing through orifice, in grams;
T = time of flow, in seconds;
H = initial or starting pressure head as read on manometer (centimeters);
h = low or contact pressure head as read on manometer (centimeters);

A = area of surface of metal in container around the tube (effective area of container), in square centimeters; and

a = inner area of tube, in square centimeters.

The apparatus used is shown in Fig. 1 and consists of a cylindrical vessel *V* 6.15 cm. in inside diameter and 15.5 cm. deep, made of cast iron. It is supported by a stand *S* upon which is fastened a ring burner *R*. A Bunsen burner *B* as shown is also used when it becomes necessary to introduce heat rapidly for control purposes. The whole furnace is incased with sheet iron and wound with asbestos. An asbestos disk with a hole cut in it to fit the vessel is fitted to the top in such a way as to leave an opening *O* so that sufficient heat may reach the top of the vessel. A hard glass tube *T*, 46 cm. long, 1.65 cm. in outside diameter with an inside area of 1.33 sq. cm., is held in position, as shown, by clamps *C*. The electrode *E* is a stout copper wire terminating in a copper cup in which is fastened a carbon contact point of about the shape shown. The electrode is held in place by a star-shape guide *G*, which fits the inside of the tube freely, and a rubber stopper *P* at the top of the T connection. The bottom of the carbon contact is adjusted to a distance of 11.25 cm. from

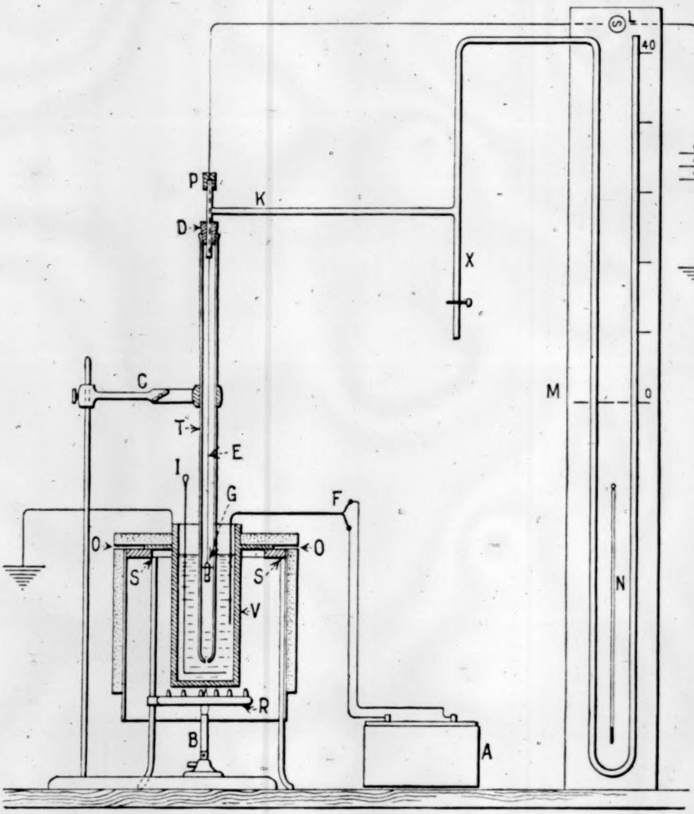

FIG. 1.—Diagram of Apparatus Used in Fluidity Test.

the orifice of the tube, which is 1 mm. in diameter. A water manometer reading to 80 cm. is connected with the tube as shown. On the panel of the manometer is mounted a 6-volt electric lamp *L* which is connected with a storage battery and the apparatus as shown.

Pressure to the tube is introduced through the rubber exhaust pipe *X* and held in the apparatus by a pinch cock. A thermocouple tube and stirring rod are introduced in the metal in the vessel and their sectional areas deducted from the effective area of the vessel for all calculations.

In operating the apparatus the tube is disconnected from the manometer at *K* and removed from the clamp. The electrode assembly is then removed from the tube by drawing out the rubber stopper *D*. The metal to be tested is then placed in the vessel *V* and melted, a sufficient quantity being used to bring the level $\frac{3}{4}$ in. below the top of the vessel. The empty tube, preheated to remove all moisture, with its orifice closed by a wood plug fastened to the end of a stiff iron wire, is forced below the surface of the metal. At the same time a piece of tallow or paraffin about half the size of a pea is dropped into it from the open end and the orifice plug removed. The clamps are then lightly set on the tube and the electrode assembly set in place by the stopper *D*. The manometer is connected at *K* and the tube lowered slowly till the lamp at *L* shows lighted. The paraffin distills away from the surface of the metal, leaving it clean and covered by an atmosphere which prevents the formation of dross. The tube then acts as a reflux condenser for the paraffin and there is no tendency toward the formation of dross or the metal adhering to the glass.

By the use of a hand pump and by raising or lowering the tube in the clamps the contact or low pressure point may be adjusted to any desired head. The liquid in the tube is then depressed by the hand pump till the prescribed high pressure or starting pressure is reached, when the pump is disconnected. Upon the release of the pinch-cock the liquid will rise in the tube and the time required for it to reach the carbon contact is noted when the signal at *L* lights. Temperatures may be controlled ordinarily by the ring burner, but upon the occasion of a repeated reading being necessary the Bunsen burner may be instantly used to hold a temperature. The metal should be thoroughly stirred between each reading and it is advisable between readings while waiting for temperature to fall to keep the column of metal in the tube in motion. This assures uniform temperature and prevents local precipitation within the metal.

RESULTS OF TESTS

In all tests made, the starting or high pressure was 76.20 cm. of water and the contact or low pressure 15.24 cm. or 30 in. and 6 in. respectively. The manometer settings were corrected for temperature to 4° C. and 1 cu. cm. of water considered as 1 g. at this temperature.

In the actual timing of flow, the contact is at the top of the meniscus of the rising metal, while the point of setting is determined when there is no meniscus because of the pressure in the tube. This should cause a short reading, but the interval of time between the flash of the signal light and the stopping of the watch should compensate this error.

The results of the tests made on the several metals are shown plotted in two series of curves. Those of Fig. 2 are curves in which times of flow in seconds are plotted against temperatures in degrees centigrade. In Fig. 3

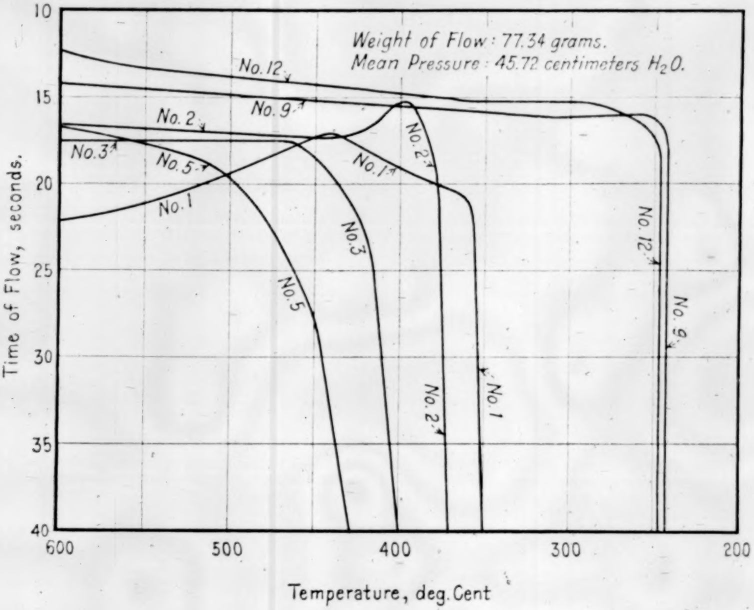

FIG. 2.—Time Temperature Flow Curves of White-Metal Bearing Alloys.

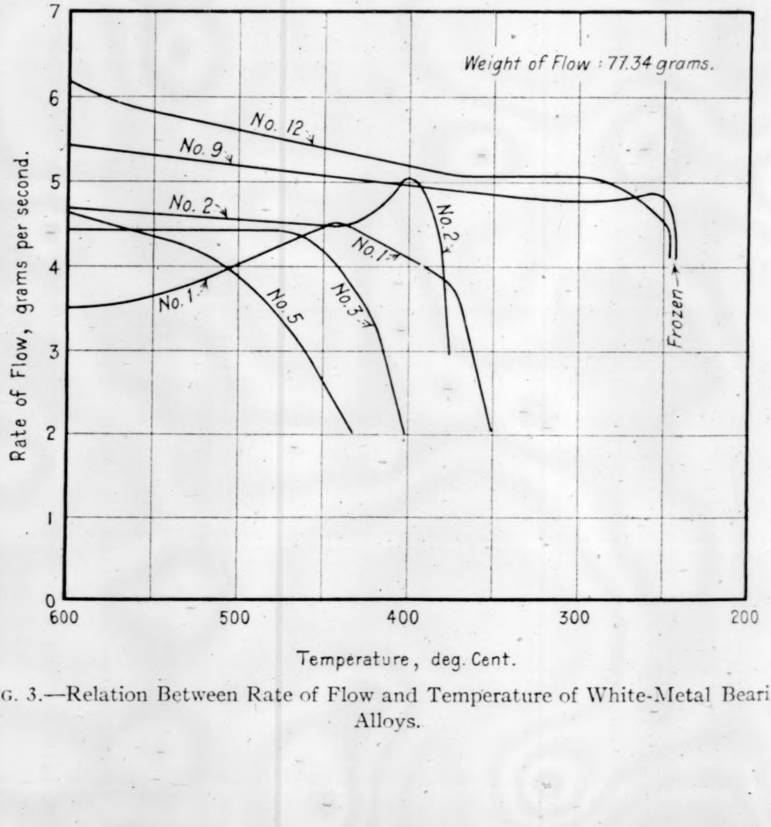

FIG. 3.—Relation Between Rate of Flow and Temperature of White-Metal Bearing Alloys.

the plotting is the rate of flow in grams per second against temperature in degrees Centigrade. Deducting 0.05 sq. cm. from A in Eq. 2 for the area of the stirring rod and thermocouple, the effective area becomes 27.51 sq. cm. and the computation is:

$$W = \frac{A}{A + a}(H - h)\,a, \text{ or } W = \frac{27.51}{27.51 + 1.33}(76.20 - 15.24)\,1.33 = 77.34 \text{ g.}$$

This weight of flow is of course the same for all metals tested since the high and low pressures are kept constant. It is the weight used in plotting the curves of Fig. 3. The points for the curves of Fig. 2 were plotted from readings taken every ten degrees in fall of temperature and three runs were made for each curve. With the exception of metals No. 1 and No. 2, the points as plotted in no instance varied as much as 0.5 seconds from the curves as drawn. Near 400° C. on metal No. 2 and between 450 and 500° C. on metal No. 1 variances from 0.6 to 1.0 seconds were encountered and the curves as plotted represent the average of the different runs. Even with these variances it is felt that the checks were surprisingly close.

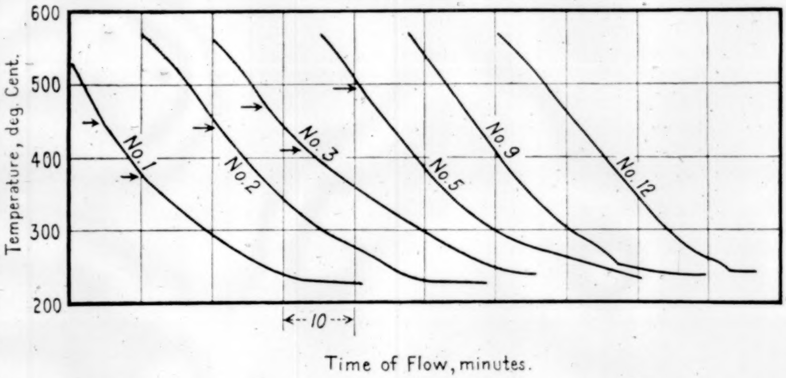

FIG. 4.—Time Temperature Cooling Curves of White-Metal Bearing Alloys.

The lead-base metals it may be noticed hold their fluidity almost to their freezing points, while the tin-base metals lose their fluidity at points from 100 to 150° C. above their freezing points. These latter metals at temperatures from 350 to 425° C. cease to flow through the 1-mm. orifice used, though from surface appearances they still seemed amply liquid at these temperatures to run. By use of a large orifice an attempt was made to determine the fluidity of these tin-base metals at temperatures below those shown. A number of readings were taken with a 2-mm. orifice, but even with this size the flow was so slow and uncertain that it was decided to abandon the attempt for the present and build a new apparatus capable of working under a 225-cm. head. This pressure will require an entirely different design of furnace, tube, and manometer connections, and will probably not be completed for several months. However the results as given, it is felt, will throw at least some light upon the questions of composition and pouring temperatures of the metals examined.

Curves No. 3 and No. 5 show results that might be expected of such metals, but curves No. 1 and No. 2 are somewhat surprising. The breaks in the cooling curves of No. 1 and No. 3, Fig. 4, explain the falling off in fluidity below 450° C., but offer no explanation of the increase in fluidity of No. 1 with the fall in temperature from 600 to 450° C. The sudden rise of curve No. 2 at 440° C. is likewise not explained by thermal analysis.

It is the author's opinion that the separation from a melt of a solid constituent may decrease or increase the fluidity or viscosity of the remaining liquid provided the quantity of the constituent separated is not sufficient to obstruct the orifice of the measuring instrument. As the quantity of separation increases it will hinder the flow through the orifice in the same manner as fine particles of sand in suspension will hinder the flow of water in a pipe. This is undoubtedly the cause of the rapid falling off of the fluidity of the copper-bearing alloys at temperatures 100 to 150° C. above their points of solidification. An examination of the fluidities of pure tin and tin-antimony alloys suggests itself as a logical step toward the explanation of curves such as No. 1 and No. 2.

The influence of the differences in specific gravity upon the relative fluidities of the metals examined is about as was expected though the variance is not in accord with an exact direct ratio. There are no figures at hand on the gravities of these metals at different temperatures in the liquid state and it is highly probable that such knowledge would assist in explaining their characteristic fluidities.

In the Appendix to the Tentative Specifications for White Metal Bearing Alloys (Serial Designation: B 23 - 18 T) will be found a table giving physical properties of these twelve alloys. In the last column of this table is given the proper pouring temperatures of the several metals. The curves of either Fig. 2 or Fig. 3 will throw considerable light upon these temperatures. It may be seen that the pouring temperature of metal No. 1 there given as 441° C. corresponds exactly to the highest point of fluidity given by the curve for that metal. The pouring temperature of metal No. 2 given in the table as 424° C., is within twenty degrees of the highest fluidity shown by the curve. For metal No. 3 the temperature given in the table is 491° C. which is at the highest fluidity and about twenty degrees above the break in the fluidity as shown by the curve for that metal. The proper pouring temperature of metal No. 5 given in the table as 366° C. does not correspond in any way with points on the fluidity curve for that metal. From the handling of this metal preparatory for tests it is believed that unless it be poured around 525° C. it will froth badly and machined surfaces of bearings made from it will show pin holes. Metal No. 5 ceased to flow in the fluidity tube at 425° C. and repeated experiments would not change that degree. The curve shows 500° C. as being the lowest permissible temperature of pouring and this is borne out in practice where very small amounts of copper are present in lead-base metals. The experience of the Chicago Bearing Metal Co. has been that on a metal of 6 to 8 per cent of tin, 9 to 11 per cent of antimony, lead difference, that a few tenths of a per cent of copper when present in the metal will cause it to froth upon pouring at any temperature below 482° C., and that a temperature considerably higher than that is advisable. Most of the copper may be removed from such a metal by sweating at a temperature of 350° C. In curve No. 5 of Fig. 4 above the break shown at 345° C. there is another abrupt change or break at 490° C. which may explain the almost continuous decrease in fluidity as measured by the fluidity tube. The pouring temperatures given for metals No. 9 and No. 12 correspond well to those that would be selected from the fluidity curves, though a temperature of 375° C. for both would seem better than 332° C. for No. 9 and 329° C. for No. 12 as given in the table.

SUMMARY

The conclusions that may be drawn are summarized as follows:

1. The difference in specific gravity of the solid metals influences their relative fluidities in the molten state.
2. The lead-base metals have a more evenly sustained fluidity above their melting points.
3. The separation of copper-tin and copper-antimony compounds from the liquid melt affect the fluidity of the melt by obstruction. (This is proved by experiments with 2-mm. orifices.)
4. There is no conclusive evidence of a viscosity changing with temperature as exists in oils and other liquids such as molten slags.

Acknowledgment.—In offering this paper to the Society the author wishes to acknowledge the able assistance and cooperation of Mr. E. M. Staples, Mechanical Engineer of the Chicago Bearing Metal Co.

REPORT OF COMMITTEE B-3
ON
CORROSION OF NON-FERROUS METALS AND ALLOYS

Since the last annual meeting of the Society, Committee B-3 has been active in carrying out many laboratory tests started during the previous year. These tests were primarily designed to test certain methods of laboratory corrosion testing which had been found to be the most generally used and which gave promise of being of most value for general application. The details of these tests and of the methods adopted for testing them have been described in the previous annual reports submitted to the Society by this committee.

In connection with these tests it became necessary to develop certain specific methods of cleaning of specimens in addition to those previously reported. A series of tests were therefore conducted and it was found that the best procedure for cleaning copper and admiralty metal specimens is as follows:

1. Wash with water.
2. While still wet rub off all removable scale with a soft cloth.
3. Dip for 30 seconds in dilute sulfuric acid (10 per cent by weight) at room temperature.
4. Dip in water and wipe off with soft cloth, to remove any remaining corrosion product.
5. Dip successively in warm water, alcohol and ether, and allow to dry at room temperature.
6. Allow the specimens to remain in the balance until they have reached the temperature of the balance before weighing. This is important.

For cleaning nickel specimens it was found that the best procedure was to dip in a 2.5-per-cent solution of sulfuric acid until bright, followed by a thorough wash in water and alcohol as previously recommended by the committee, the sulfuric acid solution being at room temperature.

It was found in some of the combinations of metals and solutions being worked with that before the set time period of duration of the test had elapsed the corroding solution became exhausted. In such cases it was decided to continue the test only until approximately 20 per cent of the solution had been exhausted.

In working with lead specimens it was found that final rinsing in ether caused some tarnishing whereas if final rinsing, after a water wash and alcohol rinse, was in carbon tetrachloride followed by drying in warm air no tarnishing resulted.

When the laboratory testing program was laid out by the committee, some 22 different laboratories agreed to carry out tests. To date, only 15 of these have actually worked on the program. Several of these 15 carried out more than one type of test. The total-immersion test was carried out in eight different laboratories, the alternate immersion test in nine, the spray test in five and the accelerated electrolytic test in five. These laboratories combined have worked on 5348 different specimens, each specimen having been carefully prepared and polished and weighed an average of 4 times. Over 21,000 weighings have thus been made and recorded. Approximately 11,300 actual laboratory man-hours have been put on the work at a total expense for labor and material, without overhead, of approximately $24,000. The work to date in these laboratories is approximately 85 per cent completed and bids fair towards being entirely completed, in so far as originally laid out, within the next two months.

The results of all of these tests are to be collected and charted and such definite recommendations and conclusions as are possible will be formulated during the coming year.

In the meantime, the committee, through the formation of a Special Program Sub-Committee has been making definite plans for its future work. Three new sub-committees are being formed, as follows:

Sub-Committee VI on Atmospheric Corrosion, to cover marine, outdoor and indoor exposures.

Sub-Committee VII on Corrosion in Liquids, to cover corrosion in natural waters, chemicals and chemical solutions, and water line corrosion.

Sub-Committee VIII on Galvanic and Electrolytic Corrosion, covering metals in contact with each other.

These sub-committees will each first review their respective fields and plan on how to carry on actual long-time service tests which can be used to study accelerated tests that may be developed. These sub-committees will also proceed to develop such suitable accelerated tests which seem to bear some direct relation to service exposure and which give some promise of results which will allow of the quick rating of the value of metals to withstand service.

This report has been submitted to letter ballot of the committee, which consists of 34 members, of whom 25 have voted affirmatively, none negatively, and 9 have refrained from voting.

Respectfully submitted on behalf of the committee,

SAM TOUR,
Secretary.

REPORT OF COMMITTEE B-4
ON
METALLIC MATERIALS FOR ELECTRICAL HEATING

On June 25, 1925, a conference was held at the headquarters of the Society to consider the advisability of the Society undertaking the development of standard methods of testing electrical heating wires. These materials have a wide application, but there is no agreement by either producers or consumers as to the methods of test for determining their properties. There has been a wide divergence of opinion as to the merits of the various grades and makes of wire due to the different methods of test employed.

At this meeting it was agreed that this work should be undertaken, and a recommendation was presented to the Executive Committee of the Society that a new committee be formed whose scope would be to deal with the properties of metallic resistors for high-temperature work.

The Executive Committee acted favorably upon this recommendation, and authorized the organization of Committee B-4 on Metallic Materials for Electrical Heating, to undertake:

1. The study of properties of such materials including chemical, physical and electrical properties and to conduct suitable investigations;
2. The development of standard methods of test; and
3. The development of standard specifications.

The committee was organized in Cleveland, Ohio, on October 27, 1925, with 10 members, including 4 producers, 4 consumers and 2 representing independent interests. Since that time, two producers have been added to the committee, one of whom is a new member of the Society.

Two meetings of the committee have been held at the U. S. Bureau of Standards, Washington, D. C., on January 25 and 26, and April 12 and 13.

It was decided to first consider resistance materials suitable for use at temperatures greater than 500° C., and to develop standard methods of test before undertaking the preparation of quality specifications.

The work of the committee has been assigned to five sub-committees, as follows:

I. On Life Tests. To determine the durability under service conditions.

II. On Physical and Electrical Tests.
III. On Chemical Analysis.
IV. On Standard Sizes and Packages. To standardize spools, labels and sizes of wire and ribbon.
V. On Application Data. To compile data on precautions to be used in application, including effect of deteriorating agencies.

PROPOSED NEW TENTATIVE STANDARDS

One new method of test has been prepared and is appended to this report[1] entitled "Method of Test for Resistivity of Metallic Materials for Electrical Heating."

It is recommended that this method be published as a tentative standard.

SUB-COMMITTEE ACTIVITIES

The details of the work can best be given by reference to the reports of the various sub-committees.

Sub-Committee I on Life Tests.—The methods of test used by a number of producers and consumers in this country and abroad to determine the durability of heating wires under service conditions have been obtained and distributed to the members of the committee for study. The various factors entering into the durability test have been considered and the following are being actively investigated:

1. Size and shape of specimen;
2. Mounting of specimen during test;
3. Measurement of temperature;
4. Character of test—whether the test should be made at constant voltage or constant temperature;
5. Continuous or intermittent test.

Sub-Committee II on Physical and Electrical Tests.—Three specifications for methods of test for resistivity, resistance per unit length and change of resistance with temperature have been outlined. Of these, the method of test for resistivity is submitted for adoption as a tentative standard. The following methods of test are under consideration:

1. Change of resistance with temperature;
2. Cold bend test;
3. Uniformity of temper;
4. Tensile strength;
5. Melting point;
6. Metallographic examination.

Sub-Committee III on Chemical Analysis.—Several methods of chemical analysis for nickel-chromium and iron-nickel-chromium alloys have been compared by the members of the committee using standard samples, with a view to the adoption of standard methods of analysis. Check tests are now being made.

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[1] See p. 738.—ED.

Sub-Committee IV on Standard Sizes and Packages.—Information as to the present practice is being obtained with a view to standardization.

Sub-Committee V on Application Data.—There is much need for information regarding the effect on metallic resistors of the various deteriorating agencies to aid in making proper application. The committee has already collected some data on this subject, and is planning to present a paper at the annual meeting of the Society in June, 1927.

GENERAL

The aim of the committee in this, its first year, has been primarily to organize for effective work, to study the various kinds of metallic materials for electrical heating, to gather the necessary data upon which to base specifications, and to prepare methods of test. Standardization necessarily requires time in a field where there has been no previous work along this line.

The committee desires to express its appreciation of the hearty cooperation which has been given the committee by a number of members of the staff of the U. S. Bureau of Standards in connection with the two meetings held at the Bureau.

The following is the result of the letter ballot vote of the committee, which consists of 12 members, on the recommendation contained in this report.

Item	Affirmative	Negative	Not Voting
Proposed Tentative Method of Test for Resistivity of Metallic Materials for Electric Heating........	11	1	0

This report has been submitted to letter ballot of the committee, which consists of 12 members, of whom 11 have voted affirmatively, 1 negatively, and none have refrained from voting.

Respectfully submitted on behalf of the committee,

DEAN HARVEY,
Chairman.

F. E. BASH,
Secretary.

EDITORIAL NOTE

The proposed Tentative Method of Test for Resistivity of Metallic Materials for Electrical Heating was accepted for publication as tentative and appears on page 738.

REPORT OF COMMITTEE C-1
ON
CEMENT

Committee C-1 on Cement has held three meetings since the last annual meeting of the Society. All were well attended and at each sub-committees presented reports showing that much work had been done through tests and investigations.

As the result, the committee recommends to the Society the Tentative Specifications and Tests for Portland Cement appended hereto[1] as a tentative revision of the present Standard Specifications and Tests for Portland Cement (C 9 - 21).[2] The tentative specifications contain certain well-defined major changes and also many minor ones. Among the suggested changes are the following:

1. The requirement for specific gravity is withdrawn from the specifications and the methods of tests for the same are eliminated.

In its report to the Society in 1924, Committee C-1 expressed the belief that this requirement should be eliminated; in 1925, the committee approved such elimination but offered it as a tentative revision pending the time when other changes might be presented to the Society by the committee.

2. The requirements for tensile strength of standard mortar briquets are increased from 200 to 225 lb. per sq. in. at the 7-day period, and from 300 to 325 lb. per sq. in. at the 28-day period.

These changes are proposed to meet an evident disposition among some users of cement to write specifications calling for a higher minimum tensile strength than required by the present standard specifications, and the changes are made in the light of an investigation made by the Sub-Committee on Strength, of Committee C-1, which sub-committee has collected reports of results of tests from a large number of laboratories testing for various interests. The tabulated results of these tests indicated that the quality of the cement being produced, with the exception of a relatively small percentage of tested material, was equal to or above the recommended new requirements. The committee accordingly offers these higher requirements in the new tentative specifications.

3. The whole specifications and methods of tests, modified as stated above and also in some minor details, have been rewritten. The phraseology used in the rewriting conforms in general to that

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[1] The tentative specifications were approved for adoption as standard and appear in the supplementary pamphlet A.S.T.M. Standards Adopted in 1926.—Ed.

[2] 1924 Book of A.S.T.M. Standards.

used by the U. S. Federal Specifications Board in its proposed Master Specifications for Portland Cement.

The committee had voted to suggest some slight changes in the general clauses and in the methods of test. By rewriting the whole as stated above and incorporating the changes at the same time, it is believed that a more perfectly written specification is presented.

The revisions in detail are as follows:

Section 3.—The requirement for specific gravity has been omitted.

Section 7.—The tensile strength has been raised from 200 to 225 lb. per sq. in. at 7 days and from 300 to 325 lb. per sq. in. at 28 days.

Section 9.—This requirement has been amended to cover shipping advices with bulk shipments and condition of packages.

Section 11.—The time allowed for completion of the 7-day test has been increased from 10 to 12 days and for the 28-day test from 31 to 33 days. The last sentence has been revised as follows by the addition of the italicized words and the omission of those in brackets:

> "The 28-day test [shall be waived only when specifically so ordered] *need not be made if waived by the purchaser.*"

Section 12.—Rejection has been made mandatory by changing "may" to "shall."

A new Section 12 has been added to read as follows:

> "Cement remaining in storage prior to shipment for a period greater than 6 months after test shall be retested and shall be rejected if it fails to meet any of the requirements of these specifications."

Section 14.—A new sentence has been added, at the end of this section, reading as follows:

> "The provisional acceptance of the cement at the mill shall not deprive the purchaser of the right of rejection on a retest of soundness and time of setting at the time of delivery of cement to the purchaser."

Section 16.—The size of test sample has been reduced from 8 lb. to 4 lb.

Section 17 (b).—The quantity of cement represented by one test sample has been reduced from 200 bbl. to 100 bbl.

Section 18 (a).—The size of sample has been reduced from 8 lb. to 4 lb. and a new sentence added reading as follows:

> "This may be secured by taking the entire test sample at a single operation, known as the 'Grab Method,' or by combining several portions taken at regular intervals, known as the 'Composite Method.'"

Section 19.—The word "moisture-proof" has been added before "air-tight" in the first sentence.

A new Section 19 has been added to read as follows:

"The sampling shall be done by or under the direction of a responsible representative of the purchaser."

Section 22.—This section has been changed in minor details.

Section 24.—This section has been changed in minor details.

Section 26.—This section has been changed in minor details.

Section 32.—The depth of the sieve has been increased from 1½ in. to 2 in. and a new second sentence added, reading as follows:

"The joint between the cloth and frame shall be smoothly filled with solder to prevent lodging of the cement."

Section 33.—The requirements for the No. 200 sieve have been brought in line with the Tentative Specifications for Sieves for Testing Purposes.

Section 34.—The last two sentences have been revised as follows by the addition of the italicized words:

"The operation shall continue until not more than 0.05 g. passes through in one minute of continuous sieving (*Note 1.*) The fineness shall be determined from the weight of the residue on the sieve expressed as a percentage of the weight of the original sample, ***applying the sieve correction*** (*Note 2.*)."

The following notes have been added:

NOTES

"1. The essential points in the sieving operation may be summarized as follows:

(1) Rotation of the sieve throughout the process.

(2) Guarding against loss of material. Sieve over white paper and always tap the sieve gently.

(3) Use of a balance which will give results correct within 5 mg. and sufficiently sensitive so that the rest point will be deflected at least two divisions of the scale for an added load of 5 mg.

(4) Washers, shot and slugs should never be used on the sieve.

(5) Excessive humidity interferes with good sieving. It tends to decrease the percentage of cement passing the sieve, and in general, to produce irregular results.

"2. A plus (+) sieve correction indicates the amount to be added to and a minus (−) sieve correction the amount to be subtracted from the per cent passing the sieve to obtain the true fineness. The per cent passing is the amount obtained by subtracting the per cent residue from 100. The corrections are used in the reverse order when applied to the residues direct."

Section 36.—The first sentence has been changed to read as follows by the addition of the italicized words and the omission of those in brackets:

"The quantity of dry [material] ***materials*** to be mixed at one time shall [not exceed 1000 g. nor be less than 500 g.] ***be 500 g. for neat cement mixtures and 1000 g. for mortar mixtures.***"

Section 37.—The requirements have been made more definite.

Section 38.—The last sentence has been revised by the addition of the italicized word and the omission of those in brackets:

"The paste is held in a *rigid* conical [, hard-rubber] ring, [G, 7 cm. in diameter at the base, 4 cm. high,] resting on a glass plate [H] about 10 cm. square."

A new sentence has been added, as follows:

"The ring shall be made of a non-corroding, non-absorbent material, and shall have an inside diameter of 7 cm. at the base, 6 cm. at the top, and a height of 4 cm."

Section 39.—The section has been changed in minor details.

Section 42.—The section has been changed in minor details.

Section 43.—The following note has been added:

"NOTE.—It is important that the specimens be 24 hours old when placed in steam, since variations in their age will produce differences in the results of the steam tests. Particularly noticeable are the effects of steaming pats too soon, for many specimens steamed when only 10 or 12 hours old give apparently satisfactory results, while failure would be observed if they were not placed in steam until 24 hours old."

Section 48.—Reference has been made to maintaining the needles in proper condition.

Section 50.—The last sentence has been revised as follows by the addition of the italicized words and the omission of those in brackets:

"Molds shall be [wiped with an oily cloth before using] *oiled with a mineral oil.*"

Section 51.—Reference to the price has been omitted.

Section 52.—The requirements for standard sand on the new Nos. 20 and 30 sieves have been included to replace the old.

Section 53.—This section has been changed to bring the requirement in line with the Tentative Specifications for Sieves for Testing Purposes.

Section 54.—This section has been completely revised to read as follows:

"Immediately after mixing the standard mortar in accordance with the methods for mixing cement pastes and mortars the molds shall be filled heaping full without compacting. Then the mortar shall be pressed in firmly with the thumbs, applying pressure 12 times to each briquet, at points to include the entire surface. The pressure shall be such that the simultaneous application of both thumbs will register a pressure of 15 lb. Each application of the thumbs shall be maintained not longer than sufficient to attain the specified pressure. Then the mortar shall be heaped above the mold and smoothed off with a trowel. The trowel shall be drawn over the mold in such a manner as to exert a pressure of not more than 4 lb. The mold shall then be turned over upon a plane plate oiled with mineral oil, and the operation of heaping, thumbing and smoothing off repeated. No ramming or tamping shall be used, nor any troweling in excess of that required to smooth off the specimen."

Section 55.—This section has been completely revised to read as follows:

"The briquets shall be tested as soon as they are removed from the water. Tests may be made with any machine meeting the following requirements: The machine shall have a capacity of 2000 lb. The sensibility reciprocal (the weight required to be added to the load to move the beam from a horizontal position of equilibrium to a position of equilibrium at the top of the trig loop) shall not exceed 1 lb. at the full capacity of the machine or at any lesser load. The machine shall be capable of weighing the applied load within 0.5 per cent of the nominal value. The clips for holding the tension test specimens shall be in accordance with Fig. 7. The bearing surfaces of the clips and briquets shall be free from sand or dirt, and the roller bearings shall be well oiled and maintained so as to insure freedom of turning. The briquets shall be carefully centered in the clips and the load applied continuously at the rate of 600 lb. per minute."

Section 57.—The word "tested" has been substituted for "broken."

Section 58.—This section has been completely revised to read as follows:

"The moist closet may consist of a soapstone, slate or concrete box, or a wooden box lined with metal. The interior wall surfaces of all closets shall be covered with felt or broad wicking kept wet. The bottom of the moist closet shall be covered with water to a depth of at least 2 in."

Section 59.—This section has been completely revised to read as follows:

"All test specimens, immediately after molding, shall be kept in the molds on plane plates in the moist closet for from 20 to 24 hours in such manner that the upper surfaces shall be exposed to the moist air."

Section 60.—This section has been completely revised to read as follows:

"The briquets shall then be removed from the molds and immersed in clean water in storage tanks constructed of non-corroding material."

Section 61.—This section has been omitted.

The report of the Special Sub-Committee appointed to make a survey of tension tests of portland cement for 1925 is appended to this report.

Committee C-1 has largely increased its membership this year in order to include in its membership members of various co-interested organizations so that such members may readily be familiar with proposals made in Committee C-1, and at the same time give to the committee their advice and help in developing and passing upon the questions before it.

In order to facilitate general consideration of the proposed revision of the standard specifications, the committee has requested the Society, as the sponsor for the cement specifications, to secure permission from the American Engineering Standards Committee for the organization of a Sectional Committee on Cement, which committee should be composed of representatives from allied interested organizations. These organizations have, in general, appointed their representatives for this sectional committee.

The committee is actively working on a number of problems. The outstanding one is the question of whether or not the standard mortar briquet is the best measure of the value of a cement. With this in mind, the Sub-Committee on Strength has been fostering a series of tests and studies to determine the practicability of substituting a very wet neat cement test specimen, either in the form of briquets for tension or cubes for compression testing. The reports on this study may be expected before long.

In addition to the actions and studies as reported above, Committee C-1 would report that it has appointed a new Sub-Committee on Sea-Water Cements and also another sub-committee to collect information and data regarding the qualities, tests, and uses of "early-hardening" cements.

This report has been submitted to letter ballot of the committee, which consists of 79 members, of whom 52 have voted affirmatively, 1 negatively, and 26 have refrained from voting.

Respectfully submitted on behalf of the committee,

R. S. GREENMAN,
Chairman.

R. B. YOUNG,
Secretary.

[For Addendum to the Report of Committee C-1, see page 218.—ED.]

APPENDIX

REPORT OF SPECIAL SUB-COMMITTEE ON SURVEY OF TENSION TESTS OF PORTLAND CEMENT FOR 1925

INTRODUCTION

At the meeting of Sub-Committee VII on Strength held in Philadelphia on March 29, 1926, the following Special Sub-Committee was appointed to make a survey of strength tests of portland cements carried out in the United States during 1925:

D. A. Abrams, Lewis Institute, Chicago, Ill. (Chairman).
R. S. Greenman, Dept. of State Engineer, Albany, N. Y.
Sanford E. Thompson, President, The Thompson and Lichtner Co., Boston, Mass.

The sub-committee was instructed to collect information from laboratories testing cement which would permit a classification of the results of standard briquet tests according to tensile strength into groups indicated in the following table:

REQUESTED CLASSIFICATION OF BRIQUET STRENGTHS

7-DAY STRENGTH, LB. PER SQ. IN.				28-DAY STRENGTH, LB. PER SQ. IN.			
Below 200	200 to 224	225 to 249	250 and over	Below 300	300 to 324	325 to 349	350 and over

On April 6, a circular letter and printed blanks were sent to 331 laboratories, requesting the above information. The laboratories were requested to identify brands or lots of cement by number; the reports are here identified only by number.

SCOPE OF SURVEY

Appended hereto is a list of 177 laboratories from which reports were received up to May 14; the map in Fig. 1 shows their geographical location. Forty-one states and three Canadian provinces are represented.

In order to study the results of this survey, the laboratories were classified into the following 5 groups:

Commercial (C)
Government, City and University (G)
Portland Cement Manufacturers (P)
Railroads (R)
State Highway Departments (S)

In a few instances cement tests made for the state highway departments were reported by the state university; those reports were included under highway departments.

The report of one state highway department was omitted for the reason that only average strengths were given; the data from 4 laboratories were omitted due to use of other than standard sand, reporting practice tests of students, etc. Tests on foreign cements reported by a few laboratories were omitted.

TABLE I.—GENERAL STATISTICS OF REPORTS FROM 172 LABORATORIES.

Laboratories	Reports Received	Brands or Mills	Tests[a]		Barrels Represented		
			Total Number	Per Cent of Total	Total Number	Per Cent of Total	Average per Sample
Commercial (C)	32	236	50 890	28.2	10 438 907	5.6	205
Government, City and University (G)	19	145	8 090	4.5	3 649 650	2.0	452
Portland Cement Manufacturers (P)	74	138	62 826[a]	34.9	153 901 003	83.4	2450
Railroad (R)	14	120	4 372	2.4	1 319 869	0.7	302
State Highway Departments (S)	33	303	53 905	30.0	15 314 003	8.3	284
Total	172	942	180 083	100.0	184 623 432	100.0	....

[a] The average strengths of 3 briquets of 1:3 standard sand mortar at 7 and 28 days tested in accordance with A.S.T.M. Standard Specifications and Tests for Portland Cement (C 9 – 21).

Table I gives general statistics of the returns from the 172 laboratories which were used.

The number of tests reported by a single laboratory ranged from 9 to 13,448; the number of barrels reported ranged from 175 to 19,464,625. The 74 reports from laboratories of portland cement manufacturers include about 95 per cent of the cement produced in 1925. About 20 per cent of the cement made during the year 1925 was subjected to tests other than by the manufacturers.

TABLE II.—PER CENT OF 1925 BRIQUETS FALLING BELOW CERTAIN STRENGTHS.

TESTED AT 7 DAYS			TESTED AT 28 DAYS		
200 LB. PER SQ. IN.	225 LB. PER SQ. IN.	250 LB. PER SQ. IN.	300 LB. PER SQ. IN.	325 LB. PER SQ. IN.	350 LB. PER SQ. IN.
0.7	5.3	17.1	0.6	4.5	13.3

The average number of barrels represented by each sample ranged from 205 for commercial laboratories to 2450 for portland cement manufacturers (see Table I).

It is obvious that in many instances duplicate tests are included on the same cement, since reports were received from both manufacturers and consumers.

DISCUSSION

The response to this questionnaire, in view of the limited time available, was extremely gratifying; all cooperating laboratories deserve the thanks of the committee for furnishing their data.

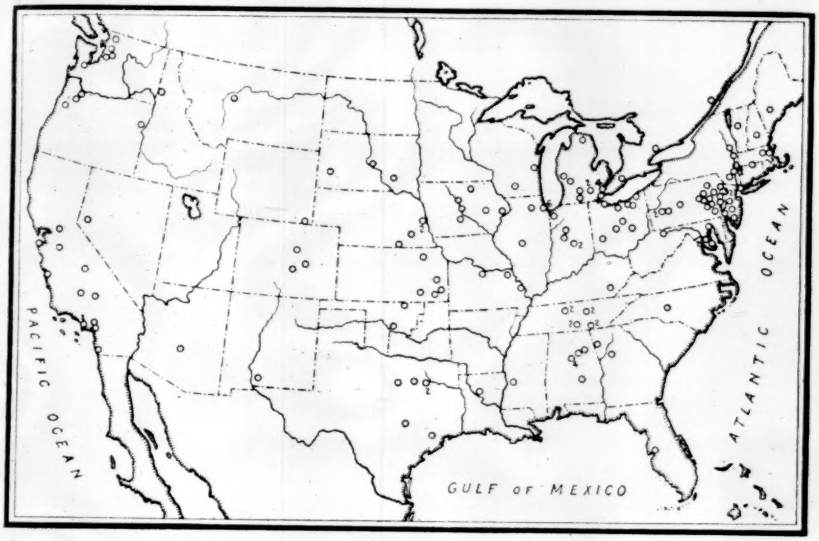
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
2

FIG. 1.—Map Showing Location of Laboratories Submitting Reports.

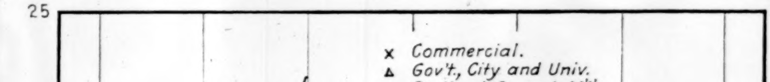

FIG. 2.—Percentages of 1925 Briquet Tests Falling Below Certain Strengths.

This survey probably constitutes the most comprehensive statistical study of cement tests which has ever been carried out since it summarizes the results of over 1,000,000 briquet tests. (Over 180,000 tests of 6 briquets each.) The returns cover practically the entire cement production of the country, and represent tests from all types of laboratories.

The commercial, railroad and state highway laboratories apparently hold closely to the sample-per-car basis. Yet comparing the results as shown by Table V with those of the portland cement manufacturers whose samples represent about 10 times as much cement, there is but a small difference in the distribution of the test results in the various strength classifications.

TABLE III.—ILLUSTRATION OF DATA SUBMITTED AND METHOD OF CALCULATING WEIGHTED PERCENTAGES.

Weighted percentages are based on the number of samples tested; the totals as in columns 10 to 13 are the values used in Table IV.

Laboratory	Brand	Number of Samples	Barrels Represented	Percentages for 7-day Tests as Submitted by Laboratory S-2					Weighted Percentages				
				Below 200 lb. per sq. in.	200 to 224 lb. per sq. in.	225 to 249 lb. per sq. in.	250 lb. per sq. in. and Over	Total	Below 200 lb. per sq. in.	200 to 224 lb. per sq. in.	225 to 249 lb. per sq. in.	250 lb. per sq. in. and Over	Total
1	2	3	4	5	6	7	8	9	10	11	12	13	14
S2...	1	40	9 950	2.08	6.25	48.00	43.67	100.00	0.1	0.3	2.0	1.8	4.2
	2	31	6 500	.....	19.40	32.20	48.40	100.00	...	0.6	1.0	1.5	3.1
	3	35	6 830	.....	2.94	17.66	79.40	100.00	...	0.1	0.6	2.9	3.6
	4	73	14 600	.....	2.08	10.40	87.52	100.00	...	0.2	0.8	6.6	7.6
	5	210	60 570	.....	18.70	37.00	44.30	100.00	...	4.0	8.0	9.5	21.5
	6	179	36 200	.....	.....	.....	100.00	100.00	...	...	...	18.2	18.2
	7	131	26 200	.....	.....	0.76	99.24	100.00	...	...	...	13.3	13.3
	8	244	45 400	.....	.....	21.70	78.30	100.00	...	...	5.4	19.4	24.8
	9	24	5 500	.....	4.00	32.00	64.00	100.00	...	0.1	0.8	1.5	2.4
	10	16	4 400	15.80	31.60	15.80	36.80	100.00	0.2	0.4	0.2	0.5	1.3
Total..	.....	983	216 180	.....	.....	.....	.....	.....	0.3	5.7	18.8	75.2	100.0

Bin tests, as indicated by the replies to the questionnaire probably account for the difference in the number of barrels per sample shown by the several types of laboratories.

Throughout this report the single test result (that is, the average of 3 briquets at 7 and 28 days) is the unit of measure.

In order to secure a quantitative measure of the results on different brands or lots of cement tested by a given laboratory and again by the different laboratories, two systems of weighting were used:

1. *For a Given Laboratory.*—The percentages of the strengths for a given brand or lot falling in each of the strength classifications were weighted on the basis of the *number of tests*. The method of calculating the percentages from the 7-day tests by one laboratory is shown in Table III; the totals from columns 10 to 13 for each laboratory in a

Table IV.—Weighted Percentages of Tests in Individual Groups.

For method of calculating the weighted percentages see Table III.

Laboratory	Samples		Number of Brands or Lots	Number of Barrels Represented	Weighted Percentages of Total Tests in Group							
					7-day				28-day			
	Number	Per Cent of Total			Below 200 lb. per sq. in.	200 to 224 lb. per sq. in.	225 to 249 lb. per sq. in.	250 lb. per sq. in. and Over	Below 300 lb. per sq. in.	300 to 324 lb. per sq. in.	325 to 349 lb. per sq. in.	350 lb. per sq. in. and Over
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
Group (C), Commercial Laboratories.												
C1	34	0.1	2	6 764	....	....	8.8	91.2	...	5.8	94.2	....
C2	1 013	2.0	10	25 600	0.6	3.4	20.2	75.8	1.5	4.5	17.1	76.9
C3	261	0.5	4	50 502	1.5	16.5	20.3	61.7	1.5	7.7	26.8	64.0
C4	524	1.0	6	108 133	2.7	44.8	26.2	26.3	0.4	23.9	38.8	36.9
C5	435	0.9	8	229 591	...	0.6	1.8	97.4	0.2	1.1	1.3	97.4
C6	227	0.4	16	58 050	0.9	1.7	8.8	88.6	2.3	6.3	21.3	70.1
C7	790	1.6	5	157 832	...	19.0	38.0	43.0	...	19.0	36.1	44.9
C8	1 758	3.4	9	621 231	0.4	9.1	25.5	65.0	0.4	5.6	22.0	72.0
C9	41	0.1	6	6 600	4.9	4.8	12.1	78.2	...	7.2	2.4	90.4
C10	479	0.9	8	105 246	...	...	...	100.0	...	...	...	100.0
C11	3 620	7.2	5	691 398	...	...	...	100.0	...	...	...	100.0
C12	9 472[a]	18.5	6	1 863 000	...	0.2	2.0	97.8	...	...	1.6	98.4
C13	3 889	7.7	19	840 652	0.4	5.6	31.0	63.0	0.4	10.8	28.8	60.0
C14	1 708	3.4	7	347 000	...	1.2	4.3	94.6	...	1.2	3.3	95.5
C15	1 020	2.0	10	272 903	...	0.8	6.4	92.8	...	1.1	3.1	95.8
C16	989	1.9	3	202 500	...	13.4	17.2	69.4	...	7.4	17.4	75.2
C17	3 648	7.1	10	627 460	...	2.6	9.3	88.1	...	0.5	4.8	94.4
C18	298	0.6	9	67 100	1.6	9.5	20.4	68.5	10.7	17.7	32.3	39.3
C19	117	0.2	7	26 300	1.7	25.7	31.6	41.0	2.6	35.1	29.9	32.4
C20	2 314	4.6	3	462 800	...	0.1	32.0	67.9	0.1	0.5	2.5	96.9
C21	389	0.8	1	77 800	...	2.6	25.2	72.2	...	1.5	11.4	87.1
C22	371	0.7	10	74 200	0.8	7.9	33.6	57.7	0.3	8.5	17.4	73.8
C23	705	1.4	1	139 449	...	3.7	21.2	75.1	1.1	9.4	28.1	61.4
C24	605	1.2	1	121 000	...	...	11.5	88.5	...	...	7.1	92.9
C25	639	1.3	2	129 256	0.3	4.9	12.2	82.6	1.4	4.5	9.7	84.4
C26	300	0.6	1	60 000	...	...	2.3	97.7	...	...	0.3	99.7
C27	1 061	2.1	10	234 000	3.4	10.0	13.1	73.5	3.2	7.3	10.0	79.5
C28	1 000	2.0	2	220 000	...	3.7	17.4	78.6	...	3.6	18.5	77.9
C29	603	1.2	13	12 400	0.4	6.3	22.4	70.9	...	3.7	6.4	89.9
C30	218	0.4	5	50 140	0.9	4.1	6.9	88.1	...	6.9	36.2	56.9
C31	10 362	20.3	24	2 051 000	2.2	9.6	15.7	72.5	2.0	10.6	11.8	77.6
C32	2 000[b]	3.9	13	499 000	0.1	2.0	22.6	75.3	0.9	9.3	16.4	73.4
Total	50 890	100.0	236	10 438 907	22.8	213.8	520.0	2443.0	29.0	220.7	557.0	2395.0
Arithmetical Averages					0.7	6.7	16.2	76.4	0.9	6.9	17.4	74.8
Weighted Percentages					0.5	4.7	14.0	80.8	0.5	4.9	10.7	83.9
Group (G), Government, City and University Laboratories.												
G1	912	11.3	6	215 561	1.2	3.9	5.5	89.4	0.2	0.2	1.6	98.0
G2	576	7.1	12	316 132	...	2.9	5.7	91.4	...	0.9	2.1	97.0
G3	581	7.2	13	164 118	...	27.8	55.6	16.6	...	8.7	23.1	68.2
G4	195	2.4	9	39 000	0.5	36.4	27.3	35.8	1.0	39.0	25.6	34.4
G5	149	1.8	4	87 800	...	14.1	20.8	65.1	...	4.0	13.5	82.5
G6	72	0.9	3	......	5.5	33.3	21.0	40.2	8.3	13.9	29.2	48.6
G7	163	2.0	12	454 300	...	1.2	7.3	91.5	...	2.4	8.6	89.0
G8	518	6.4	5	306 984	...	...	0.2	99.8	...	...	...	100.0
G9	278	3.5	5	55 600	...	...	2.9	97.1	...	...	5.8	94.2
G10	28	0.3	6	5 755	...	7.2	14.5	71.3	3.6	20.9	57.2	17.9
G11	2 542	31.4	17	698 314	0.1	0.4	1.3	98.2	...	...	0.9	99.1
G12	1 264	15.6	10	254 000	...	0.1	1.4	98.5	...	0.3	0.8	98.9
G13	282	3.5	7	434 454	...	...	...	100.0	...	...	...	100.0
G14	60	0.7	7	238 600	1.7	6.7	13.3	78.3	1.7	6.7	38.3	53.3
G15	271	3.4	4	62 571	9.2	37.7	40.2	12.9	3.0	29.7	36.3	31.0
G16	49	0.6	3	10 235	...	10.1	8.3	81.6	2.0	10.3	33.6	54.1
G17	127	1.6	15	254 725	...	2.4	7.9	89.7	...	0.8	2.4	96.8
G18	9	0.1	6	1 501	...	...	44.4	55.6	...	...	33.4	66.6
G19	14	0.2	1	50 000	78.6	21.4	.....	.....	42.9	21.4	21.4	14.3
Total	8 090	100.0	145	3 649 650	96.8	205.6	277.6	1313.0	62.7	159.2	333.8	1343.9
Arithmetical Averages					5.1	10.8	14.7	69.4	3.3	8.4	17.5	70.8
Weighted Percentages					0.6	5.5	8.9	85.0	0.4	3.1	5.9	90.6

[a] 28-day tests; 330 7-day tests.
[b] 7-day tests; 335 28-day tests.

TABLE IV.—WEIGHTED PERCENTAGES OF TESTS IN INDIVIDUAL GROUPS—(*Continued*).

Laboratory	Samples		Number of Brands or Lots	Number of Barrels Represented	Weighted Percentages of Total Tests in Group							
					7-day				28-day			
	Number	Per Cent of Total			Below 200 lb. per sq. in.	200 to 224 lb. per sq. in.	225 to 249 lb. per sq. in.	250 lb. per sq. in. and Over	Below 300 lb. per sq. in.	300 to 324 lb. per sq. in.	325 to 349 lb. per sq. in.	350 lb. per sq. in. and Over
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
				GROUP (P), PORTLAND CEMENT MANUFACTURERS.								
P1	678	1.1	1	958 166	1.8	25.4	23.0	49.8	1.2	14.5	31.3	53.0
P2	921	1.5	1	1 063 618	...	...	...	100.0	...	...	...	100.0
P3	2 028	3.2	7	14 900 000	...	...	0.1	99.9	...	...	1.7	98.3
P4	1 449	2.3	5	6 132 000	0.9	6.0	12.0	81.1	0.6	2.8	8.1	88.5
P5	391	0.6	1	1 301 997	0.8	4.9	27.3	67.0	0.3	1.0	17.6	81.1
P6	612	1.0	2	1 712 507	...	0.1	0.8	99.1	...	0.2	2.8	97.0
P7	1 080	1.7	1	910 000	...	...	1.6	98.4	...	0.1	0.4	99.5
P8	782	1.2	3	2 890 000	...	...	0.4	99.6	...	...	1.7	98.3
P9	286	0.5	1	1 145 883	...	2.1	8.0	89.9	0.7	8.8	17.2	73.3
P10	307	0.5	2	2 373 500	...	2.0	2.6	95.4	...	0.7	2.7	96.6
P11	615	1.0	1	134 024	...	0.2	0.3	99.5	0.2	1.8	6.5	91.5
P12	243	0.4	1	1 525 157	...	...	9.1	90.9	...	1.2	23.9	74.9
P13	540	0.9	1	600 000	0.6	8.5	24.3	66.6	1.3	9.6	27.4	61.7
P14	325	0.5	1	1 206 874	...	...	...	100.0	...	...	...	100.0
P15	253	0.4	1	1 055 222	0.8	4.7	15.5	79.0	0.4	4.8	17.0	77.8
P16	275	0.4	1	1 405 163	...	0.4	6.2	93.4	...	1.5	22.2	76.3
P17	1 095	1.7	1	685 307	3.0	9.7	29.4	57.9	...	6.4	15.7	77.9
P18	254	0.4	1	1 602 908	...	...	1.6	98.4	...	1.2	4.0	94.8
P19	311	0.5	1	974 910	...	...	...	100.0	...	...	...	100.0
P20	845	1.3	2	2 580 647	0.1	4.8	10.9	84.2	0.7	2.9	7.3	89.1
P21	264	0.4	1	800 000	0.4	0.4	3.0	96.2	0.8	0.8	0.8	97.6
P22	1 561	2.5	3	3 131 647	0.1	0.2	2.6	97.1	...	0.9	3.6	95.5
P23	367	0.6	1	1 340 000	0.3	2.2	9.5	88.0	0.6	3.9	9.7	85.8
P24	500	0.8	1	828 155	...	...	...	100.0	...	...	...	100.0
P25	954	1.5	1	652 392	...	...	...	100.0	...	...	...	100.0
P26	324	0.5	1	484 005	4.6	10.5	21.6	63.3	3.4	9.9	18.2	68.5
P27	677	1.1	2	1 995 000	...	...	...	100.0	...	...	...	100.0
P28	2 383[c]	3.8	2	444 891	10.9	24.3	24.0	40.8	6.0	17.7	22.4	53.9
P29	154	0.2	1	1 780 000	...	...	2.6	97.4	...	...	2.0	98.0
P30	261	0.4	1	761 834	2.3	0.8	4.2	92.7	0.8	1.2	0.8	97.2
P31	305	0.5	1	980 000	...	...	6.5	93.5	...	...	4.6	95.4
P32	750	1.2	1	881 703	...	1.5	2.3	96.2	...	...	...	100.0
P33	944[d]	1.5	4	2 072 200	0.1	2.5	12.0	85.4	0.2	3.7	7.7	88.4
P34	585	0.9	6	1 490 320	...	...	...	100.0	...	...	...	100.0
P35	428	0.7	3	1 447 816	1.2	6.2	32.8	59.8	...	2.6	9.7	87.7
P36	630	1.0	2	1 529 210	...	...	...	100.0	...	...	...	100.0
P37	360	0.6	1	378 883	...	...	...	100.0	...	...	...	100.0
P38	3 456	5.5	1	764 984	2.1	10.9	26.4	60.6	1.1	7.9	23.4	67.6
P39	75	0.1	1	128 000	...	2.7	...	97.3	...	2.7	1.3	96.0
P40	1 075	1.7	2	1 279 038	...	...	...	100.0	...	...	0.5	99.5
P41	201	0.3	1	271 000	...	...	0.5	99.5	...	...	2.0	98.0
P42	499	0.8	2	1 094 776	...	...	0.4	99.6	0.8	0.2	1.8	97.2
P43	4 402	7.1	1	15 722 000	0.1	0.8	6.7	92.4	0.1	0.4	3.9	95.6
P44	2 367	3.8	1	2 032 156	...	4.7	32.3	63.0	4.0	11.0	24.6	60.4
P45	146	0.2	1	137 464	...	...	...	100.0	...	...	2.0	98.0
P46	2 581	4.1	1	5 000 000	...	0.2	4.2	95.6	...	1.0	11.6	87.4
P47	2 701	4.3	1	1 928 063	0.1	0.1	3.1	96.7	...	...	0.1	99.9
P48	277	0.4	1	700 000	0.4	3.6	5.8	90.2	0.7	3.2	4.3	91.8
P49	742	1.2	1	2 184 338	...	...	...	100.0	...	...	...	100.0
P50	426	0.7	1	2 017 656	...	...	...	100.0	...	...	...	100.0
P51	3 405	5.4	1	550 000	...	...	...	100.0	...	...	...	100.0
P52	284	0.5	1	645 698	...	...	...	100.0	...	...	...	100.0
P53	145	0.2	1	25 960	...	...	...	100.0	...	...	...	100.0
P54	250	0.4	1	486 400	...	0.8	7.6	91.6	3.7	9.9	14.1	72.3
P55	343	0.5	1	429 364	1.1	12.2	28.7	58.0	1.5	12.9	22.8	62.8
P56	338	0.5	1	327 000	2.7	7.1	23.1	67.1	3.0	8.0	16.5	72.5
P57	2 409	3.8	9	8 987 678	0.1	4.1	20.1	75.7	0.9	5.2	22.1	71.8
P58	339	0.5	1	782 435	0.6	6.8	13.5	79.1	...	0.6	1.8	97.6
P59	1 859	3.0	6	7 081 413	0.1	1.9	5.2	92.8	...	1.1	2.4	96.5
P60	263	0.4	1	1 310 800	...	...	...	100.0	...	...	...	100.0

[c] 28-day tests; 3176 7-day tests.

[d] 28-day tests; 1068 7-day tests.

TABLE IV.—WEIGHTED PERCENTAGES OF TESTS IN INDIVIDUAL GROUPS—(*Continued*).

Laboratory	Samples		Number of Brands or Lots	Number of Barrels Represented	Weighted Percentages of Total Tests in Group							
					7-day				28-day			
	Number	Per Cent of Total			Below 200 lb. per sq. in.	200 to 224 lb. per sq. in.	225 to 249 lb. per sq. in.	250 lb. per sq. in. and Over	Below 300 lb. per sq. in.	300 to 324 lb. per sq. in.	325 to 349 lb. per sq. in.	350 lb. per sq. in. and Over
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*

GROUP (P), PORTLAND CEMENT MANUFACTURERS—*Continued*

P61	613	1.0	2	3 912 000	...	1.4	47.5	51.1	...	0.2	12.1	87.7
P62	344	0.5	1	1 730 000	...	0.3	0.3	99.4	...	0.3	0.6	99.1
P63	4 512	7.3	19	19 464 625	1.2	9.2	17.9	71.8	0.6	5.2	10.7	83.5
P64	221	0.4	1	945 400	...	7.7	16.3	76.0	...	4.1	16.7	79.2
P65	334	0.5	1	892 473	...	...	2.1	97.9	...	0.3	1.2	98.5
P66	50	0.1	1	185 000	...	4.0	16.0	80.0	...	10.0	8.0	82.0
P67	1 515	2.4	1	403 471	...	...	...	100.0	...	...	...	100.0
P68	119	0.2	1	207 682	...	8.4	15.1	76.5	...	8.6	24.2	67.2
P69	359	0.6	1	1 586 704	...	...	0.6	99.4	...	0.6	2.2	97.2
P70	254	0.4	1	398 817	...	...	1.6	98.4	...	1.2	0.8	98.0
P71	245	0.4	1	673 700	...	...	0.4	99.6	...	0.8	1.2	98.0
P72	321	0.5	1	1 189 459	...	2.2	9.7	88.1	...	...	1.6	98.4
P73	257	0.4	1	1 194 580	...	...	0.4	99.6	...	...	1.6	98.4
P74	362	0.6	1	1 084 175	0.8	3.6	8.6	87.0	...	4.4	6.4	89.2
Total..	62 826	100.0	138	153 901 003	37.2	210.1	622.7	6544.5	33.6	198.0	529.5	6638.9
Arithmetical Averages					0.5	2.8	8.4	88.3	0.5	2.7	7.2	89.6
Weighted Percentages					0.7	3.4	10.4	85.5	0.5	3.0	8.7	87.8

GROUP (R), RAILROAD LABORATORIES.

R1	301	6.9	7	69 230	...	...	...	100.0	...	...	...	100.0
R2	432	9.9	5	18 347	...	0.4	9.6	90.0	...	0.3	1.0	98.7
R3	205	4.7	10	47 355	...	8.8	29.7	61.5	...	12.7	22.4	64.9
R4	1 055	24.1	18	511 700	3.1	7.1	12.4	77.4	0.7	3.8	13.1	82.4
R5	572	13.1	10	2 500	0.2	0.4	2.1	97.3	0.2	...	0.2	99.6
R6	224	5.1	7	52 690	...	...	3.1	96.9	...	3.5	11.1	85.4
R7	82	1.9	9	13 624	...	2.4	9.8	87.8	2.4	3.6	8.5	85.5
R8	593[e]	13.6	16	421 424	3.5	11.9	25.7	58.9	2.2	15.3	16.4	66.1
R9	501	11.4	9	100 200	...	1.2	10.9	87.9	...	0.4	6.0	93.6
R10	124	2.8	6	17 525	...	3.2	4.9	91.9	0.8	4.0	10.5	84.7
R11	13	0.3	3	175	7.7	23.1	7.7	61.5	9.6	9.6	28.9	51.9
R12	29	0.7	6	6 085	...	10.3	17.3	72.4	20.7	13.8	20.7	44.8
R13	16[f]	0.4	7	8 750	...	25.1	...	74.9	15.4	30.7	7.7	46.2
R14	225	5.1	7	50 264	0.4	9.7	27.1	62.9	3.0	9.4	16.5	71.1
Total..	4 372	100.0	120	1 319 869	14.9	103.6	160.3	1121.3	55.0	107.1	163.0	1074.9
Arithmetical Averages					1.1	7.4	11.4	80.1	3.9	7.7	11.6	76.8
Weighted Percentages					1.2	4.8	12.4	81.6	0.9	4.7	9.5	84.9

[e] 7-day tests; 499 28-day tests.
[f] 7-day tests; 13 28-day tests.

GROUP (S), STATE HIGHWAY LABORATORIES.

S1	46	0.1	2	11 849	...	2.2	4.3	93.5	...	4.3	4.3	91.4
S2	983	1.8	10	216 180	0.3	5.7	18.8	75.2	0.2	2.5	12.2	85.1
S3	77	0.1	5	7 355	...	...	...	100.0	...	...	2.7	97.3
S4	205	0.4	11	34 154	2.0	18.7	31.0	48.3	7.7	20.9	34.3	37.1
S5	4 444	8.2	15	888 500	0.9	2.0	8.2	88.9	0.2	0.9	2.3	96.6
S6	88	0.2	1	18 000	...	9.1	7.9	83.0	...	2.3	8.0	89.7
S7	136	0.3	8	26 958	...	16.2	44.8	39.0	...	28.6	25.8	45.6
S8	1 174	2.2	4	235 000	0.2	3.0	13.3	83.5	0.3	2.0	7.1	90.6
S9	223	0.4	4	44 400	13.9	16.1	21.1	48.9	1.7	5.8	18.9	73.6
S10	900	1.7	12	186 419	...	10.5	21.5	68.0	...	6.5	18.3	75.2
S11	1 487	2.7	9	432 600	No 7-day tests				0.3	1.5	4.3	93.9
S12	646	1.2	11	104 613	1.0	10.3	18.6	70.1	0.6	8.4	14.7	76.3
S13	1 752	3.2	5	352 600	1.3	1.7	21.5	75.5	0.7	3.6	16.3	79.4

TABLE IV.—WEIGHTED PERCENTAGES OF TESTS IN INDIVIDUAL GROUPS—(*Continued*).

Laboratory	Samples		Number of Brands or Lots	Number of Barrels Represented	Weighted Percentages of Total Tests in Group							
					7-day				28-day			
	Number	Per Cent of Total			Below 200 lb. per sq. in.	200 to 224 lb. per sq. in.	225 to 249 lb. per sq. in.	250 lb. per sq. in. and Over	Below 300 lb. per sq. in.	300 to 324 lb. per sq. in.	325 to 349 lb. per sq. in.	350 lb. per sq. in. and Over
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
GROUP (S). STATE HIGHWAY LABORATORIES—(*Con'inued.*)												
S14	799	1.5	9	1 466 300	0.4	2.9	9.1	87.6	0.4	1.9	6.0	91.7
S15	585	1.1	2	41 359	...	...	0.4	99.6	...	...	...	100.0
S16	334	0.6	6	118 050	...	0.6	3.7	95.7	...	...	1.8	98.2
S17	1 981	3.7	16	445 725	0.1	4.3	12.5	83.1	0.8	3.0	7.3	88.9
S18	842	1.6	9	154 320	0.7	7.9	20.1	71.3	0.7	4.0	15.4	79.9
S19	149	0.3	1	29 244	...	...	1.3	98.7	...	0.7	2.7	96.6
S20	4 664	8.6	8	953 400	...	1.4	7.0	91.6	0.1	0.9	3.1	95.9
S21	496	0.9	10	99 200	1.0	7.0	17.3	74.7	1.2	7.0	14.5	77.3
S22	1 506	2.8	12	316 380	5.5	8.9	18.2	67.4	1.9	6.0	10.5	81.6
S23	343	0.6	15	108 763	0.3	5.6	15.9	78.2	1.8	7.4	11.4	79.4
S24	2 671	4.9	26	3 040 300	1.7	3.9	11.7	82.7	0.6	6.7	19.5	73.2
S25	481	0.9	13	92 205	0.6	6.3	14.6	78.5	0.4	6.2	15.5	77.9
S26	4 759	8.8	12	1 029 304	...	0.6	4.2	95.2	...	0.5	3.5	96.0
S27	6 015	11.1	16	1 219 778	0.4	2.4	11.6	85.6	0.3	1.1	4.5	94.1
S28	13 448	24.7	20	3 146 231	1.5	7.8	18.1	72.6	2.0	7.1	13.5	77.4
S29	28	0.1	6	5 306	...	10.7	10.8	78.5	...	...	14.3	85.7
S30	1 755	3.2	2	402 635	1.7	2.4	7.4	88.5	1.3	4.0	11.6	83.1
S31	394	0.7	9	84 150	1.8	20.6	36.5	41.1	2.6	11.5	21.8	64.1
S32	93	0.2	10	2 500	3.3	22.0	25.3	49.4	8.7	23.1	30.6	37.6
S33	401	0.7	4	225	...	0.2	1.5	98.3	...	...	0.2	99.8
Total..	53 905	100.0	303	15 314 003	38.6	210.8	458.2	2492.2	34.5	178.4	376.9	2710.2
Arithmetical Averages					1.2	6.6	14.3	77.9	1.0	5.4	11.4	82.2
Weighted Percentages					0.5	4.6	13.1	81.8	0.5	3.8	9.5	86.2

group were entered in Table IV. The 28-day tests were handled in a similar manner.

2. *For Laboratories in a Group.*—Weighted percentages were calculated on the basis of the total number of *tests in the group.* The method of weighting was similar to that described above; the results of this calculation are given in the totals at the end of each group in Table IV.

In addition to the weighted percentages in 2 above, a study was made of the returns from the *laboratories in a group* on the basis of arithmetical averages. The percentages of strengths falling in a group as reported by each laboratory were carefully checked. A typical example of computation of weighted percentages for a given laboratory is given in Table III. These averages are given in Table IV; they are summarized in Table V(*A*). The weighted percentages in Table V(*A*) are considered a more satisfactory basis for comparison than the arithmetical averages in Table V(*B*).

Numerous trials have shown that briquet tests carried out by different laboratories on the same cement vary widely; however, it is interesting to note that when a sufficient number of tests are made so that the data can be studied on a statistical basis, the results from the different groups of laboratories are found to be quite similar.

Table II shows the proportion of the portland cement tested in 1925 which falls below certain strengths at 7 and 28 days based on the *cumulative weighted percentages* from Table IV; the arithmetical averages are given in Table V(*B*).

TABLE V.—PERCENTAGES OF 1925 BRIQUETS FALLING BELOW CERTAIN STRENGTHS.

The weighted percentages (Part *A*) are considered a more satisfactory basis for comparison than the arithmetical averages (Part *B*).

Laboratories	Tests Reported		Barrels Represented		Percentage below Strength Shown (Cumulative Percentages from Table IV)					
					7-day Tests			28-day Tests		
	Total Number	Per Cent of Total	Total Number	Per Cent of Total	200 lb. per sq. in.	225 lb. per sq. in.	250 lb. per sq. in.	300 lb. per sq. in.	325 lb. per sq. in.	350 lb. per sq. in.
(*A*) WEIGHTED PERCENTAGES (Points plotted in Fig. 2; Solid curves show averages)										
Commercial (C)	50 890	28.2	10 438 907	5.6	0.5	5.2	19.2	0.5	5.4	16.1
Government, City and University (G)	8 090	4.5	3 649 650	2.0	0.6	6.1	15.0	0.4	3.5	9.4
Portland Cement Manufacturers (P)	62 826	34.9	153 901 003	83.4	0.7	4.1	14.5	0.5	3.5	12.2
Railroad (R)	4 372	2.4	1 319 869	0.7	1.2	6.0	18.4	0.9	5.6	15.1
State Highway (S)	53 905	30.0	15 314 003	8.3	0.5	5.1	18.2	0.5	4.3	13.8
Total	180 083	100.0	184 623 432	100.0						
Average					0.7	5.3	17.1	0.6	4.5	13.3
Omitting (P), averages become					0.7	5.6	17.7	0.6	4.7	13.6
(*B*) ARITHMETICAL AVERAGES (NOT WEIGHTED) (Averages shown by dotted curves in Fig. 2)										
Commercial (C)	Same as above				0.7	7.4	23.6	0.9	7.8	25.2
Government, City and University (G)					5.1	15.9	30.6	3.3	11.7	29.2
Portland Cement Manufacturers (P)					0.5	3.3	11.7	0.5	3.2	10.4
Railroad (R)					1.1	8.5	19.9	3.9	11.6	23.2
State Highway (S)					1.2	7.8	22.1	1.0	6.4	17.8
Average					1.7	8.6	21.6	1.9	8.2	21.2
Omitting (P), averages become					2.0	9.8	24.0	2.3	9.4	23.9

The solid curves in Fig. 2 are drawn through the weighted percentages shown in Table II; the individual points from Table V(*A*) are shown. The dotted curves in Fig. 2 show the averages only for the cumulative arithmetical averages from Table V(*B*).

Respectfully submitted on behalf of the sub-committee,

D. A. ABRAMS,
Chairman.

R. S. GREENMAN,
SANFORD E. THOMPSON.

LABORATORIES FURNISHING REPORTS.

GROUP (C) COMMERCIAL:

Allentown Testing Laboratory, Allentown, Pa.
American Bureau of Inspection and Tests, Chicago, Ill.
Conwell, E. L., and Co., Philadelphia, Pa.
Crowell and Murray, Cleveland, Ohio.
Detroit Edison Co., Detroit, Mich.
Falkenburg and Co., Seattle, Wash.
Forest City Testing Laboratory Co., Cleveland, Ohio.
Gulick-Henderson Co., Chicago, Ill.
Hanks, Abbot A., Inc., San Francisco, Calif.
Michigan Engineering Laboratory, Inc., Detroit, Mich.
Omaha Testing Laboratories, Omaha, Neb.
Osborne, Raymond G., Los Angeles, Calif.
Perry Testing Laboratory, Detroit, Mich.
Picard Laboratories, Birmingham, Ala.
Pittsburgh Testing Laboratory, Pittsburgh, Pa.
(Reports from 14 branch laboratories)
Skinner, Sherman and Esselen, Inc., Boston, Mass.
Southwestern Laboratories, Fort Worth, Texas.
Smith, Emery and Co., San Francisco, Calif.
Thompson and Lichtner Co., Inc., Boston, Mass.
Worcester, J. R., and Co., Waltham, Mass.

GROUP (G) GOVERNMENT, CITY AND UNIVERSITY:

Allegheny County, Pennsylvania, Pittsburgh, Pa.
Baltimore Bureau of Standards, Baltimore, Md.
Board of Transportation, New York City.
Bronx Parkway Commission, Bronxville, N. Y.
Chicago Testing Division, Chicago, Ill.
Delaware River Bridge, Philadelphia, Pa.
Grand Rapids, Grand Rapids, Mich.
Hydro-Electric Power Commission, Toronto, Canada.
Indianapolis City Engineering Laboratory, Indianapolis, Ind.
Iowa, University of, Iowa City, Iowa.
Lafayette College, Easton, Pa.
Los Angeles Harbor Department, Los Angeles, Calif.
National Bureau of Standards, Washington, D. C., and Northampton, Pa.
New York Board of Water Supply, New York City.
New York State Engineer's Department, Albany, N. Y.
North Carolina, University of, Chapel Hill, N. C.
Philadelphia Testing Laboratory, Philadelphia, Pa.
Portland Bureau of Standards, Portland, Ore.
Purdue University, Lafayette, Ind.
Rochester Municipal Testing Laboratory, Rochester, N. Y.
San Diego City Laboratory, San Diego, Calif.
U. S. Bureau of Public Roads, Washington, D. C.

LABORATORIES FURNISHING REPORTS—(*Continued*).

GROUP (P) PORTLAND CEMENT MANUFACTURERS:

Alabama Portland Cement Co., Birmingham, Ala.
Allentown Portland Cement Co., Evansville, Pa.
Alpha Portland Cement Co., Easton, Pa.
Ash Grove Lime and Portland Cement Co., Chanute, Kan.
Atlas Portland Cement Co., Northampton, Pa.
California Portland Cement Co., Colton, Calif.
Canada Cement Co., Montreal, Canada.
Clinchfield Corporation, Kingsport, Tenn.
Colorado Portland Cement Co., Portland, Colo.
Coplay Cement Manufacturing Co., Coplay, Pa.
Cowell Portland Cement Co., Cowell, Calif.
Crescent Portland Cement Co., Wampum, Pa.
Dewey Portland Cement Co., Dewey, Okla.
Dexter Portland Cement Co., Nazareth, Pa.
Diamond Portland Cement Co., Middle Branch, Ohio
Dixie Portland Cement Co., Richard City, Tenn.
Edison Portland Cement Co., New Village, N. J.
Fredonia Portland Cement Co., Fredonia, Kan.
Giant Portland Cement Co., Egypt, Pa.
Glens Falls Portland Cement Co., Glens Falls, N. Y.
Hawkeye Portland Cement Co., Des Moines, Iowa.
Hercules Cement Corporation, Stockertown, Pa.
Hermitage Portland Cement Co., Nashville, Tenn.
Huron Portland Cement Co., Alpena, Mich.
Indiana Portland Cement Co., Greencastle, Ind.
International Portland Cement Co., Irvin, Wash.
Kansas Portland Cement Co., Bonner Springs, Kan.
Knickerbocker Portland Cement Co., Hudson, N. Y.
Kosmos Portland Cement Co., Kosmosdale, Ky.
Lawrence Portland Cement Co., Siegfried, Pa.
Lehigh Portland Cement Co., Allentown, Pa.
Louisville Cement Co., Speed, Ind.
Manitowoc Portland Cement Co., Manitowoc, Wis.
Marquette Cement Manufacturing Co., Chicago, Ill.
Missouri Portland Cement Co., Independence, Mo.
Monolith Portland Cement Co., Monolith, Calif.
Nazareth Cement Co., Nazareth, Pa.
Nebraska Cement Co., Superior, Neb.
Newaygo Portland Cement Co., Newaygo, Mich.
North American Cement Corp., Albany, N. Y.
Northwestern States Portland Cement Co., Mason City, Iowa
Old Mission Portland Cement Co., San Juan Bautista, Calif.
Olympic Portland Cement Co., Bellingham, Wash.
Oregon Portland Cement Co., Oswego, Ore.
Pacific Portland Cement Co., San Francisco, Calif.
Peerless Portland Cement Co., Detroit, Mich.
Peninsular Portland Cement Co., Cement City, Mich.

LABORATORIES FURNISHING REPORTS—(*Continued*).

Pennsylvania Cement Co., Bath, Pa.
Phoenix Portland Cement Co., Nazareth, Pa.
Pittsburgh Plate Glass Co., Fultonham, Ohio.
Pyramid Portland Cement Co., Valley Junction, Iowa.
San Antonio Portland Cement Co., Cementville, Texas.
Sandusky Cement Co., Bay Bridge, Ohio.
Santa Cruz Portland Cement Co., Davenport, Calif.
Signal Mountain Portland Cement Co., Chattanooga, Tenn.
South Dakota State Cement Plant, Rapid City, S. D.
Southern States Portland Cement Co., Rockmart, Ga.
Southwestern Portland Cement Co., Victorville, Calif.
Standard Portland Cement Co., Painesville, Ohio.
St. Marys Cement Co., St. Marys, Ont., Canada.
Sun Portland Cement Co., Lime, Ore.
Superior Portland Cement Co., Inc., Concrete, Wash.
Texas Portland Cement Co., Dallas and Houston, Texas.
Three Forks Portland Cement Co., Trident, Mont.
Trinity Portland Cement Co., Fort Worth, Texas.
Union Portland Cement Co., Devil's Slide, Utah.
United States Portland Cement Co., Concrete, Colo.
Universal Portland Cement Co., Chicago, Ill.
Vulcanite Portland Cement Co., Vulcanite, N. J.
Warrior Cement Corp., Spocari, Ala.
Whitehall Cement Manufacturing Co., Cementon, Pa.
Wolverine Portland Cement Co., Coldwater, Mich.
Wyandotte Portland Cement Co., Wyandotte, Mich.

GROUP (R) RAILROAD:

Atchison, Topeka and Santa Fé Railway Co., Iola, Kan.
Chicago, Burlington and Quincy Railroad Co., Aurora, Ill.
Chicago, Rock Island and Pacific Railway Co., Chicago, Ill.
Delaware, Lackawanna and Western Railroad Co., Scranton, Pa.
Louisville and Nashville Railroad Co., Louisville, Ky.
Missouri-Kansas and Texas Railway, Parsons, Kan.
Missouri Pacific Railway Co., St. Louis, Mo.
New York Central Lines, New York, N. Y.
New York Central Lines, West, Collingswood, Ohio.
Northern Pacific Railway Co., St. Paul, Minn.
Pacific Gas and Electric Co., Emeryville, Calif.
Pennsylvania Railroad, Altoona, Pa.
Reading Co., Reading, Pa.
Union Pacific System, Omaha, Neb.

GROUP (S) STATE HIGHWAY DEPARTMENTS:

Arizona Highway Department, Phoenix.
California Highway Commission, Sacramento.
Colorado State Highway Commission, Denver.

Laboratories Furnishing Reports—(*Continued*).

Connecticut State Highway Department, Hartford.
Georgia State Highway Department, East Point.
Idaho, University of, Moscow.
Illinois Division of Highways, Springfield.
Indiana State Highway Commission, Indianapolis.
Iowa Highway Commission, Ames.
Kansas State Highway Commission, Manhattan.
Maine, University of, Orono.
Massachusetts State Highway Department, Boston.
Michigan State Highway Department, Ann Arbor.
Minnesota Department of Highways, Duluth.
Mississippi State Highway Department, Jackson.
Missouri State Highway, Jefferson City.
Nevada Department of Highways, Carson City.
Nebraska, University of, Lincoln.
New Hampshire Highway Department, Concord.
New Jersey State Highway Department, Trenton.
New Mexico State Highway Department, Las Cruces.
Ohio State Highway Department, Columbus.
Oklahoma State Highway Department, Oklahoma City.
Oregon State Highway Commission, Salem.
Pennsylvania Department of Highways, Harrisburg.
South Dakota State Highway Commission, Pierre.
Tennessee State Department of Highways, Nashville.
Texas, University of, Austin.
Vermont State Highway Department, Montpelier.
Washington State Highway Department, Olympia.
West Virginia State Research Commission, Morgantown.
Wisconsin Highway Commission, Madison.
Wyoming State Highway Department, Cheyenne.

ADDENDUM TO REPORT OF COMMITTEE C-1

At a meeting of the committee held on June 24 a number of minor changes were voted in the revisions of the Standard Specifications and Tests for Portland Cement (C 9 – 21) as given in the report of the committee as preprinted.

These changes are as follows:

Section 11.—Change to read as follows by changing the word "shall" to "may":

> "The cement *may* be rejected if it fails to meet any of the requirements of these specifications."

Section 17.—Change to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "(a) Individual Sample.—If sampled in cars, one test sample shall be taken from each 50 bbl. or fraction thereof. If sampled in bins one sample shall [be taken from] *represent* each [100] *200* bbl. *unless otherwise specified by the purchaser.*
>
> "(b) Composite Sample.—If sampled in cars, one sample shall be taken from one sack in each 40 sacks (or 1 bbl. in each 10 bbl.) and combined to form one test sample. If sampled in bins or warehouses one test sample shall represent not more than [100] *200* bbl. *unless otherwise specified by the purchaser.*"

Section 34.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "The temperature of the room, the materials, the mixing water, the moist closet and [storage tanks] *storage-tank water* shall be maintained as nearly as practicable at 21° C. (70° F.) and *the mixing water, moist closet and the water in the storage tank* shall not vary from this temperature more than 3° C. (5° F.)."

Section 51.—Change the pressure to be used in forming briquets from 15 lb. to "between 15 and 20 lb."

Section 52.—Change to read as follows by the omission of the words and figures in brackets and the transposition of the sentences in italics:

> "The briquets shall be tested as soon as they are removed from the water. Tests may be made with any machine meeting the following requirements: [The machine shall have a capacity of 2000 lb.] *The machine shall be capable of weighing the applied load within 0.5 per cent of the nominal value. The sensibility reciprocal (the weight required to be added to the load to move the beam from a horizontal position of equilibrium to a position of equilibrium at the top of the trig loop) shall not exceed 1 lb. at the full capacity of the machine or at any lesser*

load. The clips for holding the tension test specimens shall be in accordance with Fig. 7. The bearing surfaces of the clips and briquets shall be free from sand or dirt, and the roller bearings shall be well oiled and maintained so as to insure freedom of turning. The briquets shall be carefully centered in the clips and the load applied continuously at the rate of 600 lb. per minute."

The committee recommended that with these changes and corrections the revisions as submitted be accepted and that the specifications be approved for reference to letter ballot for adoption as standard.

Respectfully submitted,

RUSSELL S. GREENMAN,
Chairman.

R. B. YOUNG,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications and Tests for Portland Cement, submitted by the committee as complete new specifications, were amended as indicated in the addendum to the report. The revised specifications were approved and subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926. See Discussion, page 220.

DISCUSSION

[Editorial Note.—Following the presentation and adoption by the meeting of the revisions proposed in the Addendum to the Report of Committee C-1 given on page 218, the following discussion took place.]

Mr. Greenman.

Mr. R. S. Greenman[1] (*Chairman of Committee C-1*).—Those are the changes in the specifications as printed. On behalf of the committee, I would move that the proposed revised Specifications and Tests for Portland Cement, with the amendments that have been offered by the committee and approved, be now referred to letter ballot of the Society for adoption as standard to supersede the present standard specifications.

[The motion was seconded by Mr. W. K. Hatt.]

Mr. Merriman.

Mr. Thaddeus Merriman.[2]—I should like to point out that the motion made by the chairman of the committee is not in accordance with the recommendations contained in the report of the committee. The second paragraph of the committee report as printed, reads in part as follows: "As the result, the committee recommends to the Society the Tentative Specifications and Tests for Portland Cement appended hereto as a tentative revision of the present Standard Specifications and Tests for Portland Cement (C 9 - 21)."

Mr. Greenman.

Mr. Greenman.—This report, as written and approved by the committee, presented to the Society a tentative specification, but the committee is now asking in this motion that it be adopted as a standard. The reason for asking for adoption as standard is this: if this was approved as a tentative specification and was held as such during the coming year, there would be two specifications, the present standard specification and the revised specification, which the committee believes would be in this case a very unsatisfactory condition. It is to avoid this condition that the motion is presented. I do not believe this is in conflict with the report. The report includes the presentation of these as tentative standards. The committee now asks that they be made not tentative but standard.

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[1] Senior Assistant Engineer in Charge of Tests, Department of State Engineer and Surveyor, Albany, N. Y.

[2] Chief Engineer, Board of Water Supply, City of New York, New York City.

Mr. Webster. THE CHAIRMAN (*Past-President G. S. Webster*[1]).—The chair would announce that to refer this specification to letter ballot for adoption as standard will require a nine-tenths vote of the members voting at this meeting.

Mr. Mattimore. MR. H. S. MATTIMORE.[2]—In supporting this motion I wish to say that this specification as amended in the committee was given considerable discussion. We do not by any means believe it is the ideal or finished specification, but it certainly is a considerable improvement over the present standard. If this new specification were adopted as tentative and did not replace the present standard, it would lead to considerable confusion in having two cement specifications, one standard and one tentative.

Mr. Hatt. MR. W. K. HATT.[3]—I had seconded that recommendation for a practical reason and as a representative from the American Concrete Institute on the Sectional Committee on Cement, that will have to consider this amended specification for American Standard under the procedure of the American Engineering Standards Committee. It seems to me that every one is agreed now that it would be better to bring this revised specification before the sectional committee as the standard of this Society. The character of the specification itself and the practical element are the reasons for not delaying action unnecessarily on this motion.

Mr. Kelley. MR. F. W. KELLEY.[4]—I think it may be of interest to this meeting to know that Committee C-1 considered very carefully the point made by the chairman: namely, the necessity for a nine-tenths vote at this meeting to make these specifications immediately standard, as well as the point which Mr. Hatt has just mentioned, that these specifications will, in the near future, be submitted to the Sectional Committee on Cement. The individual members of Committee C-1, who in many cases will be the representatives of cooperating organizations on this Sectional Committee, I think without exception expressed themselves in favor of having this revised specification become standard before submitting it to that committee, so that the sectional committee would have what we considered the last word in standard specifications before it. This, of course, does not in any way limit the action which may be taken by the sectional committee, which, after duly considering these standards will, as I understand it, make their recommendations, which will probably lead to the approval of

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[1] Consulting Engineer, Frankford, Philadelphia, Pa.

[2] Engineer of Materials, Pennsylvania State Highway Department, Harrisburg, Pa.

[3] Professor of Civil Engineering, and Director, Laboratory for Testing Materials, Purdue University, Lafayette, Ind.

[4] President, North American Cement Corporation, Albany, N. Y.

Mr. Kelley. a new standard specification by the American Engineering Standards Committee. I mention these things so that this body may know that the action asked is not a snap judgment nor an attempt to "put something over."

Mr. Ulman. MR. M. H. ULMAN.[1]—I would request as a matter of information the date this revised specification will become effective.

The Secretary-Treasurer. THE SECRETARY-TREASURER.—In the absence of any action by the meeting postponing the date upon which the revised specification shall become effective, it becomes the official standard of the Society on and after the date on which the letter ballot vote of the Society is canvassed, which will be about September 1.

May I make one comment on what Mr. Kelley has said? Yesterday the officers of the committee discussed with the President and Secretary-Treasurer the significance of the immediate adoption of this specification as standard. The only objection that arose from the viewpoint of Society policy has been removed by the assurances given yesterday at the committee meeting and here this morning by the representatives of bodies cooperating with the Society in the Sectional Committee on Cement that adoption of the specification as standard would not be viewed as in any way prejudicial to the consideration of the specification by the sectional committee nor as an act of discourtesy to the cooperating societies. Hence we believe that the members of the Society may properly support the committee's recommendation.

Mr. Bates. MR. P. H. BATES.[2]—I have just a word or two also in connection with these specifications and the conditions under which they are being presented to the meeting. As Mr. Kelley stated, this is not a question of snap judgment or of snap action on the part of the committee presenting the specifications. They are presented here almost entirely as specifications that have been before Committee C-1 for a matter of about eighteen months, having been presented to the committee through the Society from the Cement Committee of the Federal Specification Board which prepared them, and in the due course of carrying out arrangements which have been in effect for a long period of years, of having uniformity of specifications of this Society and those of the Government. They were presented before the Federal Board took final action on them, in order to continue to maintain that cooperation between the Society and the Government. As the result of these eighteen months' deliberation, the specifications have been adopted almost *in toto;* in fact, the only change of any moment has

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[1] Assistant Engineer of Materials, Pennsylvania State Highway Department, Harrisburg, Pa.

[2] Chemist, U. S. Bureau of Standards, Washington, D. C.

Mr. Bates. been in the case of increasing the required strengths of the test specimens. I will assure you that there will be very little likelihood of the Federal Board objecting to any increase in such requirements. Hence I think you can feel assured that this is not a question at all of asking the members to pass upon a subject which has been hastily considered.

[The motion was then unanimously adopted; see Editorial Note following the Addendum to the report, page 218.—ED.]

REPORT OF COMMITTEE C-3
ON
BRICK

As a result of the discussion at the meeting of the committee held in June, 1925, the committee's work during the past year has consisted largely of a contemplated rearrangement of all specifications for brick. It seems that a certain amount of confusion has arisen in the past which it is believed may be avoided in the future if the requirements for brick are more clearly separated from the test methods. Also, if these test methods for all kinds of brick are brought into one document it will serve to call the attention of the purchaser to differences in test methods as applied to different kinds of brick.

With the above idea in mind the revision of the present standard specifications for sewer brick and paving brick has been undertaken. It is contemplated splitting the present specifications for building brick into three documents dealing with clay, sand-lime and cement brick, respectively. It is also proposed that the testing methods for all kinds of building brick be collected into a separate document. Obviously such far-reaching changes could not be accomplished in one year. The committee does not care to withdraw the present standards until the above changes shall have been completed and the committee is therefore recommending that no action in regard to any standard or tentative specifications shall be taken at present.

The committee has undertaken a study of the need for a flexure test of paving brick because of the growing tendency to reduce the thickness of this material. It is following with a great deal of interest the exhaustive program of tests of brick walls now being conducted at the U. S. Bureau of Standards in cooperation with the Common Brick Manufacturers' Association.

One of the members of the committee is engaged in a study to correlate the size of pores and the internal adhesion of bricks to show their ability to resist the action of frost. If he is successful this investigation may cause revolutionary changes in the present specifications.

During the year the committee has undertaken to prepare specifications for face brick. This subject is new and the preparation of specifications for such material is obviously difficult.

This report has been submitted to letter ballot of the committee, which consists of 37 members, of whom 31 have voted affirmatively, 2 negatively and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

T. R. LAWSON,
Chairman.

W. E. EMLEY,
Secretary.

REPORT OF COMMITTEE C-5

ON

FIREPROOFING

The last report of this committee was presented in 1922, when the committee submitted specifications for the conduct of fire tests upon columns and various revision items referring to the existing Standard Specifications for Fire Tests of Materials and Construction (C 19 – 18). The existing standard had been approved March 1, 1919, as a Tentative American Standard by the American Engineering Standards Committee. Committee C-5, therefore, in presenting its report to the Society in 1922 recommended that the proposed revisions be formally submitted to the American Engineering Standards Committee as a recommended revision. This was done, and following the regular procedure of that committee, sponsors were appointed to organize a sectional committee, which should represent all interests in the matter. This sectional committee was charged with the duty of considering the proposed revision, and any other alterations in the standard which might be deemed advisable. The sponsors selected were the American Society for Testing Materials, the U. S. Bureau of Standards, and the "Fire Protection Group," the latter being composed of the National Board of Fire Underwriters, the Underwriters' Laboratories, National Fire Protection Association, and the Associated Factory Mutual Fire Insurance Companies. In due course, a sectional committee of twenty members and various alternates was organized, and proceeded to its study of the specifications. The chairman of Committee C-5 was selected as chairman of the sectional committee, and Mr. Fitzhugh Taylor of the Underwriters' Laboratories was chosen as secretary.

It soon became apparent that further revisions than those submitted by Committee C-5 were necessary, and so a complete revision of the existing standard was undertaken. The committee held numerous meetings during the past three years, and has given much careful consideration to its subject. It has completed its work, at least so far as the scope of its present study is concerned, and has prepared a report which is being submitted to its sponsor bodies with the recommendation that, if approved by them, the report be presented to the American Engineering Standards Committee for consideration as a Revised Tentative American Standard.

Committee C-5 is submitting the report[1] to the Society at this time, with the recommendation that it be accepted as a Tentative Standard for one year, to supersede when adopted the present Standard Specifications for Fire Tests of Materials and Construction (C 19 - 18).[2] This will give opportunity for correction of any defects or omissions which may develop in the interim.

As all but three members of the committee are represented on the sectional committee, it is felt that the report can be properly offered as an expression of the committee's action.

It will be noted that the title of the sectional committee report is more definite than that of Committee C-5. A change of the title of the committee to conform to that recommended by the sectional committee is a matter worth consideration. The committee suggests that such change be made.

This report has been submitted to letter ballot of the committee, which consists of 21 members, of whom 19 have voted affirmatively, none negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

IRA H. WOOLSON,
Chairman.

RUDOLPH P. MILLER,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Fire Tests of Materials and Construction were accepted for publication as new tentative specifications and appear on page 761.

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[1] The new Tentative Specifications for Fire Tests of Building Construction and Materials (Serial Designation: C 19 - 26 T) appearing on p. 761.—ED.

[2] 1924 Book of A.S.T.M. Standards.

REPORT OF THE SECTIONAL COMMITTEE ON FIRE TESTS OF MATERIALS AND CONSTRUCTION

The committee in presenting this report deems it proper to give a brief chronological history of the origin and growth of the present proposed specifications[1] which are the essential part of the presentation.

The original specifications were prepared by Committee C - 5 on Fireproofing in the American Society for Testing Materials and presented to that Society in 1907, 1908 and 1909, being revised and supplemented during that period. They covered only the conduct of tests upon floors and partitions. In 1916, a joint committee, consisting of representatives from the following technical bodies, was organized to revise the specifications:

American Society for Testing Materials,
National Fire Protection Association,
U. S. Bureau of Standards,
National Board of Fire Underwriters,
Underwriters' Laboratories,
Associated Factory Mutual Fire-Insurance Companies,
American Institute of Architects,
American Concrete Institute,
American Society of Mechanical Engineers,
American Society of Civil Engineers,
Canadian Society of Civil Engineers.

This was done and the specifications thus revised were formally adopted by the American Society for Testing Materials and the National Fire Protection Association as a Tentative Standard in 1917, and advanced to Standard in 1918. They were also endorsed by the other cooperating organizations.

The principal feature of that revision was the establishing of a standard time-temperature control curve for regulating test furnace temperatures, also a system for classifying the fire resistance of a material or construction according to the length of time it withstood the test fire.

Following the foregoing dispositions of the specifications, the American Society for Testing Materials, acting as sole sponsor, presented the specifications to the then newly organized American Engineering Standards Committee for adoption. That organization, after duly scrutinizing the personnel and method of operation of the joint committee which had done the work, found that they conformed so closely to its own rules of procedure governing the preparation of specifications, and waived further formalities and adopted the specifications as a Tentative American Standard on March 1, 1919. Increasing experience in the art of fire testing, coupled with the development of enlarged and refined test furnaces, notably at the Underwriters' Laboratories and at the Bureau of Standards, soon demonstrated the necessity for further revision of the specifications. This was undertaken by Committee C-5 on Fireproofing, and a revised report, including requirements for column tests, was presented to the American Society for Testing Materials in 1922 and accepted as a tentative standard. At the same time, the committee recommended that the proposed revision be formally submitted to the American Engineering Standards Committee as a recommended revision of its Tentative American Standard. This was done, and following the regular procedure of the American Engineering Standards Committee, sponsors were appointed to organize the sectional committee which should represent all interests in the matter, the sponsors being the American Society for Testing Materials, the U. S. Bureau of Standards and the Fire Protection Group.

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[1] Tentative Specifications for Fire Tests of Building Construction and Materials (C 19 - 26 T), see p. 761.—Ed.

An organization meeting of the representatives of the three sponsor bodies was held June 8, 1923. At this meeting the necessity for the creation of the sectional committee and its latitude was discussed, at the same time a list of suggested member bodies and independent experts was prepared, and invitations were extended to accept membership on the sectional committee. The list of members and alternates of the sectional committee thus formed is appended as a part of this report.[1] The sectional committee organized for work May 2, 1924. Ira H. Woolson, the chairman of Committee C-5 on Fireproofing in the American Society for Testing Materials, was elected as chairman and Fitzhugh Taylor as secretary.

The committee has held seven extended meetings. Details of the specifications have been carefully studied and considerable research work has been done, notably by the Bureau of Standards in establishing basic principles to be used in determining the allowable limits of test requirements and the practical application of test appliances.

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[1] For the complete personnel of the sectional committee, see p. 292 of the 1926 A.S.T.M. Year Book.—ED.

The specifications recommended by the committee have been printed and distributed as preprints of reports presented at the annual meetings this year of the National Fire Protection Association and the American Society for Testing Materials, which organizations have now adopted them in tentative form. They represent a very complete revision of the present Tentative American Standard in the American Engineering Standards Committee, accompanied by the new and revised material submitted in 1922–1923, together with additional sections prepared by the committee.

Salient new features of the regulations now recommended include more accurate furnace control; definite requirements for placing and protecting temperature-reading elements on unexposed surfaces of test structures; limitation on average temperature rise on unexposed surfaces, also at individual points where such limits are involved in "Conditions of Acceptance"; duration of fire tests to the exact period for which classification is desired; and inclusion of requirements for testing roofs, also for finish on walls, partitions and ceilings.

It is believed that the specifications as now presented are not only more comprehensive in scope than the existing standards, but are more practical in application, and the conclusions drawn from the test results will indicate more accurately what might be expected under service conditions.

This report has been submitted to letter ballot of the committee, with the result that twenty have voted affirmatively, none negatively, and two have refrained from voting.

The committee offers the specifications for favorable consideration and if they meet with the endorsement of the sponsors it recommends that they be presented at an early date to the American Engineering Standards Committee as a Revised Tentative American Standard.

Respectfully submitted on behalf of the sectional committee.

IRA H. WOOLSON,
Chairman.

FITZHUGH TAYLOR,
Secretary.

REPORT OF COMMITTEE C-6
ON
DRAIN TILE

The principal activity of the committee during the past year has been a continuation of the research investigations, begun in 1921, on the effect of alkali soils and waters on concrete drain tile. This is part of the committee's study of the need for, and form of, standard chemical tests for drain tile subjected to alkali and acid conditions. It was found necessary to make a study of the nature and extent of the alkali attack on various concretes before a test requirement could be formulated. The investigations now under way should furnish the data necessary for the formulation of a test requirement and in addition much valuable information relative to the manufacture of a resistant drain tile. Although considerable progress has been made, the data available are not yet sufficient to warrant or to permit of the formulation of specifications.

The committee considered also reports of a study of the uniformity and distribution of pressure between the tile and the bearing when "sand" bearings are used, and of the results of tests of a number of reinforced concrete pipe.

This report consists mainly of abstracts of reports on research studies which were presented at a meeting of the Committee on February 19, 1926, at Chicago:

I. IOWA ENGINEERING EXPERIMENT STATION

A. Studies with Bureau of Standards Tile

This research was conducted under the immediate direction of Mr. W. J. Schlick, Drainage Engineer of the Station staff. This research has been completed, and a complete report will probably be published as a Station Bulletin in the near future.

The main purpose of the investigation was the development of a test method for determining the durability of concrete drain tile in alkali soils. The work was done with tile from the reserve stock of tile prepared for the field study of concrete tile in alkali soils, started in 1913 by the U. S. Bureau of Standards and cooperating agencies.

The principal tests consisted of a study of the actions of solutions of the various salts common to natural alkalies on pieces from tile from 15 of the 21 series prepared for the field investigation. The 15 series chosen were shown by the earlier field examination to cover the full range from the most to the least durable.

Five tile of each of the 15 series were subjected to the standard strength test, and as many standard absorption samples as possible were taken from the segments of the tested tile. Three pieces from each tile were subjected to the standard absorption test, and three to a 72-hour immersion absorption test that was standard except for the immersion treatment. Previously, samples from the check tile, tested at the time of the 1919 field examination by Mr. G. M. Williams of the Bureau of Standards, were subjected to the standard freezing and thawing test.

The tests with the alkali solutions were made by immersing one piece from each tile (75 pieces to a set) in the following solutions: 2, 5, 10, and 15-per-cent sodium sulfate; 10 and 15-per-cent magnesium sulfate; 10-per-cent sodium and magnesium chlorides; and 15-per-cent sodium carbonate. Additional studies were made by immersing pieces from each of the absorption tests in a 10-per-cent solution of sodium sulfate, and by subjecting one piece from each tile to alternate immersion in a 15-per-cent solution of sodium sulfate and drying. A record was kept of the rate and character of the action over a period of three years for the immersed specimens, and for 222 complete treatments of the specimens alternately immersed and dried.

The results of these studies can be summarized as follows:

1. The results of these tests are in general agreement with those of the field studies made with the same series of tile.

2. Both these and the field studies seem to indicate that none of these series will have an unlimited life under severe natural alkali conditions.

3. The methods followed in these tests, namely, immersion in 15-per-cent solutions of sodium and magnesium sulfate and the alternate immersion and drying, can be used as test methods for determining durability in natural sulfate alkalies, but the duration of the tests will be too long to make it suitable for any except general plant tests. Because of peculiar susceptability of certain series to attack in each of these three tests, all of them must be used, unless it is known that the product is to be subject to attack in only one or two of them.

4. The results of the laboratory and field studies do not warrant a conclusion as to the duration of the test necessary to determine a truly durable tile. The results do indicate that any tile that shows serious action after immersion for 52 weeks in 15-per-cent magnesium sulfate or for 78 weeks in 15-per-cent sodium sulfate, or after 52 alternate immersions in 15-per-cent sodium sulfate and drying will not have an unlimited life in soils with any considerable concentration of natural sulfate alkalis.

5. The action with the chloride and carbonate solutions was so slow that these salts need not be considered, except in cases where the natural alkali is almost devoid of sulfates.

6. The results of these studies agree with those of other agencies in showing that the sulfates are the most damaging of the salts common to natural alkalies, and that the action, except for a few series, is much more rapid with magnesium sulfate. They also show that for both sulfates the action is more rapid with the higher concentrations.

7. In each of the three sulfate tests, the rate of action on certain series was much more rapid than would be indicated by the actions in the other tests. This was true for Series 6 and 8 in magnesium sulfate, for Series 16 and 21 in sodium sulfate, and for Series 2 and 15 in the alternate-immersion and drying test.

8. There was a wide variation in the rate of attack upon the pieces from the

five tile of a series in some solutions. The five pieces from the five tile from Series 5 failed in 15-per-cent magnesium sulfate in from 4 to 156 weeks.

9. The variation in resistance must be due to chemical or physical properties resulting from differences in manufacture, but to properties not shown by ordinary tests.

10. If there be any general relationship between the results of the standard physical tests for drain tile and their durability in alkali soils, for these tile it is either very general or is obscured by other variables.

11. The effects of alkali salts, as measured by these tests, are partly the results of physical action; for the specimens continually immersed, this physical action must be the result of chemical actions.

B. Chemical Studies

In addition to the investigation summarized above, chemical tests were made by Mr. G. W. Burke, Chemist of the Experiment Station staff, to determine the nature of the chemical reactions that took place when high-alumina cement, in a finely divided state, was treated with the alkali sulfates. Further, information was desired as to the extent and rate of such reactions as compared with those taking place with portland cement.

Neat briquets that had set under water for three weeks were ground to pass a 100-mesh sieve. This material was analyzed, and known amounts were treated with solutions of magnesium and sodium sulfate of about 5-per-cent concentration. The treatments were consecutive and carried out in such a manner that analyses of the effluents made it possible to ascertain the composition of the cement at any time. The results of such treatment can be summarized as follows:

1. In intimate contact with high-alumina cement, magnesium sulfate forms relatively large quantities of calcium sulfate and precipitates within the residue a chemically equivalent amount of hydrated magnesia. The reaction is the same as that which takes place when portland cement is similarly treated, but it proceeds more slowly and to a smaller extent.

2. The reactions brought about by magnesium sulfate treatment resulted in an increase in both weight and volume of the cement. The increase was much smaller than that brought about by portland-cement treatment.

3. With sodium sulfate treatment, calcium sulfo-aluminate was formed. An amount of sodium hydroxide was formed which attacked the alumina of the cement, forming soluble sodium aluminate, which resulted in more than 40 per cent of the total alumina of the cement being attacked.

4. The volume increase due to sodium sulfate treatment was slight.

Chemical tests were also made by Mr. Burke to determine the value of carbon dioxide treatment as a preventative against sulfate disintegration. Briquets, 3:1 by weight, made up of portland cement, standard Ottawa sand and distilled water, were allowed to set in a damp atmosphere of carbon dioxide for a month. The cement was separated from the sand and treated as above described with 5-per-cent solutions of magnesium and sodium sulfate.

The following information was obtained:

1. With the magnesium sulfate treatment, the total lime reacted upon was 75.6 per cent, leaving 24.4 per cent unattacked. With uncarbonated cement, a similar experiment showed that 96 per cent of the lime was attacked.

2. With the sodium sulfate treatment, a marked decrease as to the extent of the attack was obtained.

3. As it is possible to carbonate the lime of portland cement by sodium carbonate treatment, immersion in weak solutions of such a material should render the concrete more resistant to sulfate attack.

II. U. S. BUREAU OF PUBLIC ROADS

In cooperation with the Department of Agriculture, University of Minnesota, and the Department of Drainage and Waters, State of Minnesota, the Bureau of Public Roads, U. S. Department of Agriculture, is continuing the investigations relative to drain tile at University Farm, St. Paul, Minn., under the direction of Mr. D. G. Miller, Drainage Engineer.

About 20,000 concrete cylinders and 2500 concrete drain tile have been made for this study. Five thousand cylinders were stored in the laboratory at the University Farm in tap water, which is very low in total salts, and are to be used as a check against the field installations.

Nine thousand cylinders were made for exposure to the sulfate waters of Medicine Lake, South Dakota, and 4000 of them have been stored in the lake in about five feet of water. The lake water carries a total salt content consisting almost entirely of sulfates with a seasonal average not far from 4.5 per cent.

Four installations of drain tile have been made in connection with the sulfate studies, as follows: (1) a check installation of 440 tile in University Farm was laid from 4 to 6 ft. deep in clay with sand and gravel subsoil, very low in alkali salts; (2) on a private farm in Lyon County, Minn., 395 tile are laid from 5 to 6 ft. deep, at which depth the soil water carries about 0.5 per cent of total salts, largely sulfates; (3) along the margin of an alkali slough in Cass County, N. D., 260 tile are laid about 1.5 ft. below the ground surface, at which point the soil water carries about 1.5 per cent of total salts, rich in sulfates; and (4) along the margin of Medicine Lake, 430 tile are submerged below ice action. In the first three installations, the tile are rarely completely covered by water, but are moist at all times.

For the study of the effect of peat soils upon concrete, 3600 cylinders and 940 drain tile were installed at several sites in Minnesota and Wisconsin in peat soils whose analysis showed a range of organic matter content of from 80 to 93 per cent, and of mineral matter, or ash, from 20 to 7 per cent, of which the lime content ranged from 4 to 0.5 per cent. The cylinders and tile were laid at depths varying from 20 in. to 6 ft. In some installations, the specimens are covered by water at all times; in others, they are rarely completely covered by water, but are moist at all times.

No complete report has been issued of the work so far done, although several papers of the general nature of progress reports have been printed, covering different phases of the work. The most recent of these, dealing with the field installations at Medicine Lake, South Dakota, appeared in the October, 1925, issue of *Public Roads* under the title "The Action of Sulfate Water on Concrete," and is a summary of the tests of specimens after one year in Medicine Lake.

In general it may be said that one of the outstanding features of the alkali work continues to be the very satisfactory condition of all concrete cylinders cured in steam in a temperature near 212° F. (100° C.). This applies both to specimens after four years in artificial solutions in the laboratory and to specimens after 1½ years in Medicine Lake. Results obtained with high-alumina cement is another feature of the alkali work which at this time is perhaps of more than usual interest. Three brands of high-alumina cement have been used in this work, and all tests to date seem to indicate that cements of this type are perhaps somewhat more resistant to the action of sulfate waters than are most standard portland cements. These cements are not, however, 100 per cent resistant, and as to date no tests have been made after longer periods of exposure than two years, results of later tests must be awaited before conclusions of any considerable value can be drawn.

Studies recently have been made in the laboratory of various test bearings used in the testing of drain tile, and in this connection a method has been developed by which is shown the distribution of pressure on both top and bottom quadrants of circular pipe when under load in the A.S.T.M. standard sand bearings as specified for testing sewer pipe and drain tile.[1] Results indicate somewhat greater bending moments than heretofore assumed at the bottom of circular pipe when under load in the sand bearings, and this moment may vary considerably under the same total load due to several factors which have been studied.[2]

III. TESTS AT UNIVERSITY OF NEBRASKA

Mr. G. R. Chatburn gave a brief report on some series of tests of concrete culvert tile now under way at the University of Nebraska. These tile, some forty in number, varied in size from 18 in. to 48 in. in diameter, with thicknesses of shell ranging from 2.5 in. to 5.6 in. Some of the tile had one line and some two lines of reinforcement. All circular tile were tested with the standard 3-edge bearing, and deflections were taken horizontally and vertically at each end. There was one series of flat bottomed or D-shaped culverts. These were, with one exception, tested with a sand bearing at the bottom. Nearly all tile larger than 18 in. tested, having a single line of reinforcement, failed to meet the strength requirements. The Nebraska State Department of Public Works, for whom these tests were made, is revising its specifications, and a new series of tests will be made.

The data of all the tests have not yet been thoroughly worked up, but a summary is given below:

SUMMARY OF COMPRESSION TESTS ON REINFORCED CONCRETE CIRCULAR CULVERT PIPE.

Maximum Load in Pounds Carried by Pipe (Three-edge bearing).

Series	Type of Reinforcement	Size of Pipe, in.					
		18	24	30	36	42	48
A	Single	8 215	8 710	9 465	14 060	......	15 370
B	Single	6 860	8 210	10 185	10 335	......	......
C	Single	9 465	9 140	7 850	7 225	......	8 370
D	Single	8 710	11 090	10 830	12 730	......	15 935
E	Double	......	17 560	21 570	23 040	22 275	28 255
F	Single	10 610	9 615	8 800	8 345	......	9 460
G	Single	9 360	10 370	10 180	7 865	......	14 390
H	......	......	9 335	......	......	......	......

NOTE.—The values given are for sections 4 ft. in length. To obtain the load in terms of pounds per linear foot times diameter of pipe in feet, divide the values by 4*D*, where *D* is the diameter of pipe in feet.

Calculated sand bearing strength can be obtained by multiplying three-edge bearing results by $\frac{10}{7}$.

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[1] 1924 Book of A.S.T.M. Standards, pp. 677, 688 and 699.

[2] See paper by D. G. Miller and P. C. McGrew, "Determination of Pressure Distribution on Circular Pipe When Tested in the A.S.T.M. Standard Sand Bearings," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II (1926).

Committee C-6 regrets the resignation of Mr. E. H. Berger, who has severed his connection with the U. S. Bureau of Standards which he represented on the committee. Mr. P. H. Bates has been appointed to fill the vacancy caused by Mr. Berger's resignation.

At the meeting of the committee in Chicago, the committee voted to increase its membership to include Mr. W. J. Schlick and Mr. D. G. Miller, both of whom have been very active in the research work of the committee.

It is with much pleasure that the committee reports the approval of the A.S.T.M. Standard Specifications for Drain Tile (C 4 – 24) as "American Standard" by the American Engineering Standards Committee on December 14, 1925.

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 13 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

ANSON MARSTON,
Chairman.

G. W. PICKELS,
Secretary.

REPORT OF COMMITTEE C-7
ON
LIME

Committee C-7 has held two regular meetings since the last annual meeting of the Society.

The various activities of Committee C-7 are grouped below in order of the respective sub-committees.

Sub-Committee II on Lime for Structural Purposes.—Tentative Specifications for Quicklime for Structural Purposes (C 5 – 24 T)[1] are recommended to the Society for advancement to standard. These specifications have been tentative for two years during which time no criticisms have been received and this action is therefore recommended.

The sub-committee has compiled and studied existing information and has obtained further original data on the fineness of hydrated limes in connection with present sieve requirements as given in the Standard Specifications for Hydrated Lime for Structural Purposes (C 6 – 24). This study indicates that the present requirements are in accord with the best information available.

Members of the sub-committee are cooperating with members of other organizations in an effort to prepare specifications for sand for plastering.

A report on tests of plaster panels made at the U. S. Bureau of Standards is presented in Appendix I to this report.

Sub-Committee III on Lime for the Chemical Industries.—This sub-committee has prepared preliminary drafts of specifications for:

1. Quicklime and Hydrated Lime for the Defecation and Purification of Sugar Juices and Syrups;
2. Quicklime and Hydrated Lime for the Manufacture of Calcium Arsenate.

Specifications for Lime for Glass and for Lime for Causticizing are being prepared.

Specifications which are being considered by the Government Interdepartmental Conference on Chemical Lime have been discussed and criticisms presented.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 802 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 198.

Sub-Committee IV on Agricultural Lime.—Members of this sub-committee are cooperating with others on solubility tests of liming materials. The data will be of use in preparation of specifications for lime for agricultural purposes. The results are being published through other channels giving wider distribution in the agricultural field.

Sub-Committee V on Methods of Tests.—This sub-committee finds it necessary to make the following changes in Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 - 25 T):[1]

Change the heading "Determination of Silica" to "Determination of Silica and Insoluble Matter Including Silica" and change the first marginal heading now reading "Silica" to read "Silica and Insoluble Matter."

In the third paragraph under this heading change the last three sentences from their present form: namely,

> "Correct the weighed silica for foreign matter by evaporating with 5 cc. of HF and one or two drops of H_2SO_4. Heat the residue for 2 or 3 minutes in an electric muffle and again weigh. The difference between this weight and that previously obtained gives the weight of the silica (Note 4)."

to read as follows:

> "The increase in weight represents the insoluble and siliceous matter and is reported as insoluble matter, including silica.
>
> "*Silica:*
>
> "To determine the amount of silica (SiO_2), treat the 'insoluble matter, including silica,' in the crucible with 5 cc. of water, 5 cc. of HF and one or two drops of H_2SO_4,[2] and evaporate to dryness. Heat the residue for 2 or 3 minutes in an electric muffle and again weigh. The difference between this weight and that previously obtained gives the weight of 'silica' (SiO_2) (Note 4).
>
> "If the silica is determined by volatilization with HF, the residue in the crucible is fused with a little Na_2CO_3, and the cooled melt is dissolved in diluted HCl and the solution added to the filtrate from the second evaporation for 'insoluble matter, including silica.' If the 'insoluble matter including silica,' is reported as such and no HF treatment is given, the 'insoluble matter including silica' is not fused or further treated.
>
> "*Insoluble Matter, Excluding Silica:*
>
> "The difference between the weight of 'insoluble matter, including silica,' and 'silica' represents the 'insoluble matter, exclusive of silica.'"

Under "The Determination of the Total Iron and Aluminum," omit the first two sentences of the first paragraph, reading as follows:

> "Fuse the residue from the silica determination using a little Na_2CO_3 (Note 5). Dissolve the cooled melt in HCl and add the solution to the filtrate from the second evaporation for silica."

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[1] ***Proceedings***, Am. Soc. Testing Mats., Vol. 25, Part I, p. 618 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 233.

[2] See ***Bulletin** No. 700*, U. S. Geological Survey, p. 103.

Change the third sentence to read as follows by the addition of the italicized words:

> "*To the HCl solution from the determination of silica* add a few drops of bromine water or HNO_3 and boil the solution until all trace of bromine or chlorine is gone."

The above changes are essentially editorial, in that they tend to clarify the method as at present printed and to differentiate between "silica" and "insoluble matter including silica," and therefore were not submitted to letter ballot.

Omit the entire paragraph under "Determination of Total Sulfur" and substitute the following:

> "Weigh 1 g. of a properly prepared sample. Add approximately 0.5 g. of sodium carbonate. Mix thoroughly in a porcelain crucible and heat gently until sintered. Then ignite for 15 minutes at a temperature of approximately 1000° C., taking care to allow access of air to the contents of the crucible. Cool and place the crucible in a 250-cc. beaker and cover with hot water. Add 10 cc. of bromine water, then 30 cc. of hydrochloric acid (1:1) and boil until solution is complete and all bromine has been expelled. Remove the crucible, washing it with water. Add a few drops of methyl red, and render the solution alkaline with ammonium hydroxide (1:1). Boil the solution for 1 or 2 minutes, filter and wash with hot water. To the filtrate add 5 cc. of hydrochloric acid (1:1), adjust the volume to about 200 cc., bring the solution to boiling and while boiling add 10 cc. of hot 10-per-cent barium chloride solution. Allow to stand over night. Filter, wash with hot water, ignite and weigh as $BaSO_4$.
>
> NOTE.—It is usually desirable to make a fusion in a platinum crucible. However, it has been found that with limestones very high in impurities, when the fusion is made in a muffle, the damage to platinum ware is considerable. It has been proved that the use of porcelain crucibles introduces no appreciable error."

This revision has been submitted to letter ballot of the committee with the results shown in the tabulation at the end of this report.

The sub-committee presents the form shown in Appendix II for reporting "Analysis of Limestone or Lime Products" as a revision of the Tentative Methods of Chemical Analysis (C 25 – 25 T). This has been submitted to letter ballot of the committee with the result shown in the tabulation at the end of this report.

Members of the sub-committee are conducting research work to develop standard methods for measuring:

1. Sand carrying capacity of lime mortars;
2. Bulking properties of hydrated lime;
3. Rate of settling of milk of lime suspensions, and correlation of such data with industrial operations;

4. Fineness of particles of hydrated lime smaller than can be measured with a sieve;
5. Absorption of base plates for the plasticimeter; and also
6. Methods for determining the quantity of free lime in hydrated lime.

Sub-Committee VII on Lime for Highways.—This sub-committee is being reorganized with Mr. C. R. Stokes of the National Lime Association, as chairman.

Committee C-7 recommends the approval by the Society of the several recommendations contained in this report and tabulated below with the results of the letter ballot vote of the committee.

Items	Affirmative	Negative	Not Voting
TENTATIVE SPECIFICATIONS TO BE ADVANCED TO STANDARD			
Quicklime for Structural Purposes (C 5 - 24 T)	29	0	7
REVISION OF TENTATIVE STANDARDS			
Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime (C 25 - 25 T):			
1. Method for Determination of Sulfur	17	1	18
2. Form for Reporting Analyses	17	1	18

This report has been submitted to letter ballot of the committee, which consists of 36 members, of whom 21 have voted affirmatively, none negatively, and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. C. BERRY,
Chairman.

R. P. BROWN,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Quicklime for Structural Purposes were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed revisions of the Tentative Methods of Chemical Analysis of Limestone, Quicklime and Hydrated Lime were accepted. The tentative specifications as thus revised appear on page 770.

APPENDIX I

THE EFFECT OF CERTAIN MATERIALS IN THE FINISH COAT OF PLASTER

In February, 1922, there were erected at the U. S. Bureau of Standards 98 panels of plaster in the finish coat of which were incorporated various materials which were selected as being likely to cause trouble if present. This investigation was sponsored by Committee C-7 on Lime of the American Society for Testing Materials; the panels erected by the Contracting Plasterers' National Association; the materials furnished by the National Lime Association; the plaster applied by the Operative Plasterers' International Union; and the Bureau conducted the necessary laboratory work, furnished the space for the panels and made the examinations of their condition. A report indicating the procedure employed in the erection of the panels, the ingredients, sizes and amounts used in the finish coats and the condition of the panels at the end of 12 months' exposure has already been published.[1] However, at the end of three years, that is, on March 4, 1925, in order to accelerate, if possible, any hydration effect, the panels were thoroughly soaked and allowed to dry before examination. This treatment seemed to have the desired effect and while there have been slight changes in some of the panels since the application of the water, their condition when last examined, at the end of four years, was not appreciably different from that at the end of three years.

The condition of the panels at the end of four years was as follows:

Hydrate No. 1 (Ohio), plus core, (ground limestone), panels Nos. 1 to 4 and Nos. 50 to 53.—All panels are in good condition, indicating that the material employed was not harmful in any size. However, it should be noted that the material used was not "core" in the sense that it was the interior of underburned stone but was crushed unburned stone. It is possible that the former material would have given different results.

Hydrate No. 2 (Ohio), plus sand, panels Nos. 5 to 8 and Nos. 54 to 57.—There appears to be no change in the condition of these panels since the first year, and therefore the conclusions drawn then are pertinent, namely, that all the sizes of the particular sand employed cause a small amount of pitting, not sufficient to be troublesome, the coarser grains loosening first. However, the duplicate panels do not check this except in the coarse size.

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[1] Emley and Berger, *Journal* Am. Ceramic Soc., Vol. 6, No. 9, p. 1007 (1923).

The action may probably be attributed to differential expansion and contraction causing the sand grains to loosen and fall out, for there is no indication of the crater-shaped hole found in typical "pops." The results of the tests do not agree in the laboratory, and are at variance with experience, and it is believed that further detailed study is necessary on this subject before any final conclusions can be drawn.

Hydrate No. 3 (Ohio) plus over-burned lime, panels Nos. 9 to 12 and Nos. 58 to 61.—In the case of the coarse material, complete disintegration of the finish coat has occurred, with the fine blisters. The effect is very marked in all cases.

Hydrate No. 4 (Pennsylvania), plus magnesia, panels Nos. 13 to 16 and Nos. 62 to 65.—Inasmuch as the hydrate employed in these panels was of itself unsound, no conclusions can be drawn relative to the effect of the "light calcined" or "caustic" magnesia used. It might be of interest to record that hydrates Nos. 1, 2, 3, 4, 6, 9 and 11 are dolomitic and therefore contain the usual hard-burned magnesia.

Hydrate No. 5 (Vermont), plus iron carbonate, panels Nos. 17 to 20 and Nos. 66 to 69.—Iron carbonate seems to tend to cause unsoundness. However, the pops are small and would not be serious.

Hydrate No. 6 (Ohio) plus quicklime, panels Nos. 21 to 24 and Nos. 70 to 73.—The hydrate used in these panels was not entirely sound. Nevertheless, it is apparent that coarse quicklime is deleterious. With the fine material the popping is not so marked.

Hydrate No. 7 (Texas), plus pyrite, panels Nos. 25 to 28 and Nos. 74 to 77.—Pyrite when coarse causes popping but when fine is not bad.

Hydrate No. 8 (California), plus magnesium sulfate, panels Nos. 29 to 32 and Nos. 78 to 81.—This material causes no popping or cracking but does give rise to slight efflorescence.

Hydrate No. 9 (Pennsylvania), plus sodium chloride, panels Nos. 33 to 36 and Nos. 82 to 85.—Sodium chloride when fine causes excessive efflorescence, diminishing as the size is increased.

Hydrate No. 10 (Maine), plus lime burned during hydration, panels Nos. 37 to 40 and Nos. 86 to 89.—The material used in these panels caused popping except when in the finely divided state.

Hydrate No. 11 (Ohio), plus mica and tannic acid, panels Nos. 43 and 92 (fine mica), panels Nos. 44 and 93 (fine tannic acid).—Mica has no effect. Tannic acid prevents proper hardening, discolors badly and leaves the panels with innumerable "fire-cracks."

Hydrate No. 12 (Tennessee), plus clay, panels Nos. 45 to 48 and Nos. 94 to 97.—Tennessee ball clay was employed in these panels. It does not cause any popping but does tend to cause cracking, particularly in the coarser sizes.

Hydrate No. 13 (Missouri), panels Nos. 49 and 98.—This hydrate was unsound.

SUMMARY

The following materials when added in the amount of 10 per cent by weight of the finish coat have no effect, regardless of size:

Core (ground limestone);
Mica.

The following materials cause efflorescence:

- Magnesium sulfate;
- Sodium chloride.

The following materials tend to cause unsoundness, but not seriously if fine:

- Iron carbonate;
- Iron sulfide (pyrite);
- Lime burned during hydration.

The following material will always give trouble, regardless of size:

- Over-burned lime.

The following material is deleterious for special reasons:

- Tannic acid.

No information was obtained upon the following material:

- Caustic magnesia.

Two of the hydrates submitted were found to be unsound.

CONCLUSIONS

As stated previously, there have been some changes in the condition of the panels during the second, third and fourth years. However, it is not believed that these have been sufficient to justify any changes in the recommended basis for a specification for the soundness of hydrated lime, which is repeated[1] for emphasis:

> "Examine microscopically to insure the absence of calcium oxide (index of refraction = 1.81).
>
> "Wash the sample through a No. 50 sieve. Dry and weigh the residue and figure it as per cent of the sample. If the residue is more than 5 per cent, it should be analyzed. If this is found to contain less than 90 per cent calcium carbonate, the shipment represented by the sample should be rejected.
>
> "Pyrite can hardly occur in lime, but may be a constituent of the sand. A specification for sand is required, which should also carry limits on the quantity of salt and organic matter permissible."

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[1] For the original statement of the specification, see Emley and Berger, *Journal*, Am. Ceramic Soc., Vol. 6, No. 9, p. 1007 (1923).

APPENDIX II

ANALYSIS OF LIMESTONE OR LIME PRODUCTS

(Name of company)

Date .... Lab. No. ....
Name .... Date Rec'd ....
Material ....
Sample Marked ....

CONSTITUENTS DETERMINED

Name	Formula	Per cent
Silica	SiO_2	
Iron oxide	Fe_2O_3	
Aluminum oxide	Al_2O_3	
Calcium oxide	CaO	
Magnesium oxide	MgO	
Total sulfur	S	
Sulfur trioxide	SO_3	
Phosphorus pentoxide	P_2O_5	
Carbon dioxide	CO_2	
Water, at 120° C	H_2O	
Water, total	H_2O	
Insoluble		
Loss on ignition		
Available lime		
Total neutralizing value in terms of $CaCO_3$, Calculated		
Total neutralizing value in terms of $CaCO_3$, Determined		
Plasticity		
Soundness		

CONSTITUENTS CALCULATED [a]

Name	Formula	Per cent
Calcium carbonate	$CaCO_3$	
Calcium hydroxide	$Ca(OH)_2$	
Magnesium carbonate	$MgCO_3$	
Magnesium hydroxide	$Mg(OH)_2$	
Calcium sulfate	$CaSO_4$	

(*a*) Method for calculation *must* be noted for each constituent.

SIEVE ANALYSIS

Sieve No.						
Opening in microns						
Per cent passing						

REMARKS

NOTE.—Unless otherwise noted all determinations have been made according to methods prescribed by the American Society for Testing Materials.

Signed ....

REPORT OF COMMITTEE C-8
ON
REFRACTORIES

Committee C-8 has held three general meetings during the year, one of these in connection with the meeting of the American Ceramic Society at Atlanta, Ga.

The committee has no new standards to recommend at the present time but wishes to recommend the revision of two existing standards.

It recommends in the Standard Definitions for Clay Refractories (C 27 – 20)[1] the deletion of references to the test for linear contraction or expansion. This consists in the deletion of Section 3 comprising the reference to the test to be used and Sections 5, 9, 11 and 13 covering the requirements in the case of clay brick, siliceous brick, intermediate duty brick and moderate duty brick, respectively. The remaining paragraphs should be renumbered accordingly.

The committee makes these recommendations for the following reasons:

In the Standard Definitions for Clay Refractories (C 27 – 20), allowable permanent linear expansion upon reheating at 1400° C. for five hours is limited to a maximum of 1 per cent for high, intermediate and low heat duty. At the time these definitions were first proposed, it was thought that a definite relation existed between expansion and other properties such as low refractoriness and deformation under load because of the assumption that expansion was brought about by the formation of vesicular structure.

It is now known that expansion is influenced by a number of physical factors, such as degree of burning, fineness of grinding, density, etc., and also that it may occur as "secondary" expansion with brick containing clays of the highest quality. Expansion of the latter kind is influenced by the rate of heating during the test and by the application of a slight load at the time of testing. With a load of 1.4 lb. per sq. in., brick may show normal behavior which would otherwise expand by as much as 3.5 per cent on a linear basis. In fact, the amount of expansion is influenced by the method of placing in the test kiln, brick on end expanding considerably less than those laid flat. This "secondary" expansion is found on a considerable percentage of the first quality fire-clay brick manufactured in this country. In view of these facts, it appears that the expansion limits are undesirable and should be deleted.

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[1] 1924 Book of A.S.T.M. Standards.

This recommendation has been submitted to letter ballot of the committee with the following results: Affirmative, 33; negative, 0; not voting, 13.

The committee recommends the revision of the Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action (C 38 - 21 T)[1] consisting in the deletion of Section 2 (*c*) which refers to the preliminary test treatment and a change in Section 3 (*a*) so that the hot end of the brick will be immersed to a depth of 2 in. instead of 4 in. as at present specified. The committee makes these recommendations for the following reasons:

With immersion of the test samples in 4 in. of water, fractures frequently occur at distances of 4 in. or more from the heated end. This occurs at times with a few brick from one lot and not on others from the same lot, leading to widely variable and erratic results. The effect of immersion at depths of 4, 2 and 1 in. has been studied on several brands of brick and it has been found that dipping in 2 in. of water produces gradual disintegration without large pieces breaking off. This method, therefore, gives more uniform results and permits of better differentiation between two lots of brick than where the tentative procedure is followed.

The reheating treatment prior to spalling that the tentative method requires is also open to sufficient objection that it should be deleted from the tentative method. It is well known that brick which are given a soft or medium burn give better satisfaction in service where severe spalling conditions exist than hard-burned brick of similar composition and also that the degree of burning necessary to give the maximum resistance to spalling is not the same with all clays. The reheating treatment vitiates this important property.

It is also the case that brick which have been reheated spall in a comparatively small number of heating and cooling cycles and the difference in results obtained on two lots of brick which differ considerably in spalling properties as judged by the life in service may be less than the variations due to the testing method. It is true that vitrification affects spalling (and an attempt is being made to devise a spalling test which will take vitrification into account) but since it is a function of time as well as temperature and varies in rate with different clays, it is obviously impractical to ignore the effect of time in the way the reheating treatment does.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 577 (1921); also 1925 Book of A.S.T.M. Tentative Standards, p. 250.

It is recommended, therefore, that the tentative method for spalling be revised so that the test brick will be immersed in 2 in. instead of 4 in. of water, and that the reheating treatment prior to spalling be deleted. This recommendation has been submitted to letter ballot of the committee with the following results: Affirmative, 33; negative, 0; not voting, 13.

The committee submits for publication as information the Proposed Specifications for Clay Refractories for Malleable Furnaces with Removable Bungs and for Annealing Ovens appended hereto. These are the results of cooperative work with the American Malleable Castings Association and the American Refractories Institute.

During the past year, the committee has continued the study of conditions surrounding refractory service in the industries and presents appended to this report the report of the Industrial Survey Committee on Open-Hearth Practice and a report on the Conditions Surrounding Refractory Service in the Copper Industry and Conditions Surrounding Refractory Service in the Lead Industry.

During the past year, the committee has arranged through cooperation with the U. S. Bureau of Standards for the preparation of standard samples of burned high-aluminous materials. The committee has secured the cooperation of the Baltimore and Ohio Railroad; Pittsburgh Testing Laboratory; General Refractories Co.; American Refractories Institute; General Electric Co.; Illinois Steel Co.; Department of Chemistry, University of Illinois; Schools of Mines and Metallurgy, University of Missouri; the Marquette Cement Manufacturing Co. and the United Gas Improvement Co. A number of analyses have been already received, but the committee is not in a position to publish the result of this work which, since it was done in cooperation with the Bureau of Standards, will have to await the completion of the work.

During the past year, considerable cooperative work has been done in connection with the determination of fusing point of samples of refractories. This work has been initiated by Mr. Booze of the American Refractories Institute and appears to indicate that the methods for conducting the softening point test are not sufficiently standardized to give thoroughly definite results. Differences as great as two cones have been found on identical samples by two laboratories, both of whom are experienced in making such determinations, and who used the approved method. This means that the methods of testing must be more carefully defined or that liberal allowances for error in softening points must be made.

Mr. Booze has also investigated the question of spalling of fire-clay brick, as a result of which he has prepared a paper entitled "A Study of the Spalling Test for Fire-Clay Brick," which paper appears as Appendix V to this report.

This report has been submitted to letter ballot of the committee, which consists of 46 members, of whom 31 have voted affirmatively, none negatively, and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. H. FULWEILER,
Chairman.

F. A. HARVEY,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Definitions for Clay Refractories were accepted for publication as tentative and appear on page 1128.

The proposed revisions of the Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action were accepted. The tentative methods as thus revised appear on page 784.

APPENDIX I

PROPOSED SPECIFICATIONS FOR CLAY FIREBRICK FOR MALLEABLE FURNACES WITH REMOVABLE BUNGS AND FOR ANNEALING OVENS

Purpose and Utility of Specifications.—The purpose of these specifications is the selection of clay firebrick that are suitable for service in malleable furnaces under general conditions of operation and of furnace design. However, use of these specifications shall not relieve the buyer of all responsibility in the selection of the refractories best suited for his particular practice. Of the brands which may meet the requirements some will give better service than others. One brand may give best results in one plant, and another brand in another plant; and a given brand may give highly satisfactory results in one plant, and fail to do so in another. The reason for this variability in results lies in the almost countless combinations of conditions which exist in plant operation. Some of the factors which directly or indirectly influence the life of the brick are the following:

A. Factors dependent upon fuel or firing:
- Character and kind of fuel;
- Character of ash or fluxing ingredients;
- Quantity of ash or fluxing ingredients;
- Method of firing;
- Character of blast and length of flame;
- Pressure of blast;
- Direction of flame and impinging of flame upon brickwork.

B. Factors dependent upon furnace design or construction:
- Rise and span of arch;
- Type of bung frame;
- Care taken and method followed in laying brick and building bungs;
- Tightness with which brick are clamped in bung frames;
- Kind of clay used in laying brick;
- Thickness of walls.

C. Factors dependent upon character of charge:
- Kind and amount of scrap used;
- Amount of foreign material and rust on scrap;
- Percentage of pig in charge.

D. Factors dependent upon operating conditions:
- Method of charging;
- Operating temperature;
- Duration of melting period;
- Size of heats and number of heats per day;
- Care taken and method followed in handling bungs;
- Positions of brick in furnace and practice followed in shifting bungs.

The specifications do not include a requirement for slag resistance, although evidence indicates that the brick, and especially the sidewall brick, should be resistant to the corrosive action of slag. In the light of present knowledge, however, none of the slag tests that have been proposed can be regarded as satisfactory for malleable practice.

The bungs and sidewalls must withstand high operating temperatures. This is ensured by the softening point requirement. They must be resistant to rapid temperature changes, hence the spalling test requirement. The spalling requirements for sidewalls have been made less stringent than for bungs, as the spalling conditions are less severe. Sidewall brick must also withstand slag action at the slag line and the brick which are most resistant to slagging do not usually withstand spalling to the highest degree. Practical experience has shown that in bungs and sidewall brick the silica content should not be excessively high. This is cared for by imposing a maximum limit on the percentage of silica. A minimum limit is placed upon the cold breaking strength, merely to ensure that the bung brick shall be strong enough to withstand clamping in the bung frames, and to withstand shipping and handling without excessive scuffing. It is recognized that high strength is not necessarily desirable.

Revision of the requirements is to be expected as methods of testing are further perfected, and as the effect of operating conditions upon the life of the brick becomes better understood. Clay firebrick which fail to meet the requirements of these specifications may be regarded as unsatisfactory for general malleable practice.

1. *Scope.*—These specifications are intended to cover only burned products made from fire clay by the usual processes of manufacture and containing not more than 55 per cent alumina or 85 per cent silica. Even within this range of composition, it is not intended to include products other than those regularly sold as clay firebrick.

SIZE TOLERANCE

2. Variations (plus or minus) of 2 per cent from specified dimensions covering both shrinkage and warpage shall be allowed on dimensions of 4 in. or over. On dimensions under 4 in., 3 per cent variation shall be allowed.

TEST REQUIREMENTS

BUNGS

3. (*a*) *Analysis.*—The silica content shall not exceed 65 per cent.

(*b*) *Softening Point.*—The softening point shall not be below cone 31.

(*c*) *Spalling.*—Brick as shipped, after subjection to an average of 18 dips in the spalling test, described below, shall not show a loss of more than 20 per cent of their original weights.

(*d*) *Cold Strength.*—The cold modulus of rupture shall not be less than 200 lb. per sq. in.

SIDEWALLS AND BRIDGEWALLS

4. (*a*) *Analysis.*—The silica content shall not exceed 65 per cent.

(*b*) *Softening Point.*—The softening point shall not be below cone 31.

(*c*) *Spalling.*—Brick as shipped, after subjection to an average of 9 dips in the spalling test, described below, shall not show a loss of more than 20 per cent of their original weight.

(*d*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show a contraction of more than 1.5 per cent of the original length.

FIREBOX LININGS AND LOWER STACK LININGS

5. (*a*) *Softening Point.*—Non-siliceous grade:[1] The softening point shall not be below cone 31.

Siliceous grade: The softening point shall not be below cone 28.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1400° C., maintained at this temperature for 5 hours and cooled, they shall not show a contraction of more than 1.5 per cent of the original length.

UPPER STACK LINING

6. (*a*) *Softening Point.*—The softening point shall not be below cone 28.

(*b*) *Volume Change.*—When duplicate samples are heated uniformly to a temperature of 1350° C., maintained at this temperature for 5 hours and cooled, they shall not show a contraction of more than 1.5 per cent of the original length.

ANNEALING OVEN FIREBOX

7. For this service the same requirements shall hold as are given for firebox linings of malleable furnaces.

ANNEALING OVEN CHAMBER

8. (*a*) *Softening Point.*—The softening point shall not be below cone 16.

(*b*) *Linear Change.*—When duplicate samples are heated uniformly to a temperature of 1150° C., maintained at this temperature for 5 hours and cooled, they shall not show a contraction of more than 1.5 per cent of the original length.

METHODS OF TESTING

9. The determination of silica content shall be made in conformity with the analytical methods described in the Standard Methods of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick (Serial Designation: C 18–21) of the American Society for Testing Materials.[2]

10. The softening point shall be determined according to the Standard Method for Softening Point of Fire-Clay Brick (Serial Designation: C 24–20) of the American Society for Testing Materials.[2]

In the event that the material fails to pass the specified requirements by one cone or less, two additional softening point determinations shall be made as checks on the accuracy of the test and the final results judged on the basis of the three determinations. This procedure is necessary because of variations that have been found to exist in this test even where the standard methods are followed.

11. (*a*) The spalling test shall be conducted on standard 9-in. straight brick, or standard 9-in. or 13-in. bung brick. This test shall be conducted as

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[1] Brick are considered as being of non-siliceous grade when the silica content is 70 per cent or less and of siliceous grade when the silica content is greater than 70 per cent.

[2] 1924 Book of A.S.T.M. Standards.

follows: The brick as received at the testing laboratory shall be heated in the door of a suitable furnace which is being held at a temperature of 1350° C. (2462° F.). The heated end of the brick shall be flush with the inner face of the furnace wall and the outer ends shall be exposed to the free circulation of air.

(*b*) At hourly intervals the hot ends of the brick shall be immersed in running water to a depth of 2 in. for 3 minutes. The brick shall then be removed, allowed to steam in the air for 5 minutes and returned to the furnace door. This cycle shall be repeated until each brick shall have lost the required amount or until the total number of immersions necessary to give the required average has been obtained. Individual samples are not to be continued in the test after a loss of 20 per cent has been sustained. The brick shall be dried and weighed before and after testing and the loss computed as a percentage of the original dry weight.

(*c*) The results in the spalling test for any one brand shall be reported as the average loss of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done 5 additional specimens shall be tested in the event that the first 5 do not meet the requirements, and the results reported as the average of the entire 10.

12. (*a*) The modulus of rupture shall be determined in accordance with the method for modulus of rupture of building brick, as described in Section 5 of the Standard Specifications for Building Brick (Serial Designation: C 21-20) of the American Society for Testing Materials.[1]

(*b*) The results in the modulus of rupture test for any one brand shall be reported as the average of 10 specimens selected at random. If desired, the test may be made on only 5 specimens, but when this is done an additional 5 specimens shall be tested in the event that the first 5 do not pass the specifications, and the results reported as the average of the entire 10.

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[1] 1924 Book of A.S.T.M. Standards.

APPENDIX II

INDUSTRIAL SURVEY OF CONDITIONS SURROUNDING REFRACTORY SERVICE IN THE COPPER INDUSTRY

This survey covers the smelting and refining of sulfide copper ores. Such ores are found in the United States, largely in Montana, Utah, Nevada, California and on the Atlantic Coast. The raw ore found contains a relatively small percentage of copper, on the average 1.5 to 4 per cent.

In order to assure economic smelting operation, it is necessary to concentrate the ore before smelting. The concentration is a grinding and flotation process, purely a mechanical one. Upon concentration, the copper content reaches as much as 30 per cent, iron being about 25 per cent, and silica 32 per cent. Silica, together with impurities such as lime, alumina, zinc, lead, etc., makes up the balance of the ore.

Object of Smelting.—The ores thus consist largely of copper sulfide, iron sulfide and gangue, the latter being rock. The aim of the smelting process is to separate the copper from the iron, sulfur and gangue.

Basis of Smelting and Outline of the Process.—Copper has a weak affinity for oxygen in comparison with iron and other base metals in the ore and a strong affinity for sulfur. This fact, together with the fact that Cu_2S and Cu_2O will react with each other giving copper and sulfur dioxide, gives a base for the smelting process.

The various operations are roasting, smelting, converting, and refining.

ROASTING

The ore is first roasted to drive off part of the sulfur. The sulfur of the copper and iron sulfide combines with the oxygen in the air and this passes off as a gas. Not all of the sulfur is removed, as a certain percentage is desired for the smelting process as described below. The object of this process is to oxidize sulfur and iron and to remove volatile impurities, such as arsenic, antimony and bismuth.

Roasting is done in a great many ways: in heaps, stalls, shaft, reverberatory, muffle furnaces and blast roasting apparatus.

Heap roasting, of course, calls for no refractories of any kind, and, in fact, refractories play very little part in any form of roasting. The temperatures reached are not much in excess of 1500° F. (815° C.), and the chief requisite of the roasting is that the furnace (whichever type is used) be lined with a material of slight refractoriness and high mechanical strength. Red brick, as well as portland cement, are used very extensively except in those parts of the furnace where very low temperatures are reached.

In respect to furnace types, the shelf burner shaft kiln has taken the lead to such an extent that only this particular type is discussed. There are some variations with the McDougall furnace, such as the Herreshoff, O'Brien, Evans-Klepetko and the Wedge. These variations are, however, chiefly in regard to some mechanical phase of the method of operation and for the purpose in hand, the McDougall type of furnace may be considered as being representative of all.

Figure 1 shows the general design and working features of this furnace. The furnace is constructed of super-imposed parts, the ore being fed into the top and transported from shelf to shelf down through the furnace by means of a mechanical rake. In some cases, fireboxes are used at the shelves to start the roasting and in this case fire brick, of what we might term "intermediate heat duty," serves very well. Where fire brick are used at all in the parts of the shelves of the furnace, a low-grade brick of considerable mechanical strength meets the requirements. After the furnace is once started, the necessary heat for the reaction is furnished largely through the burning sulfur in the ore.

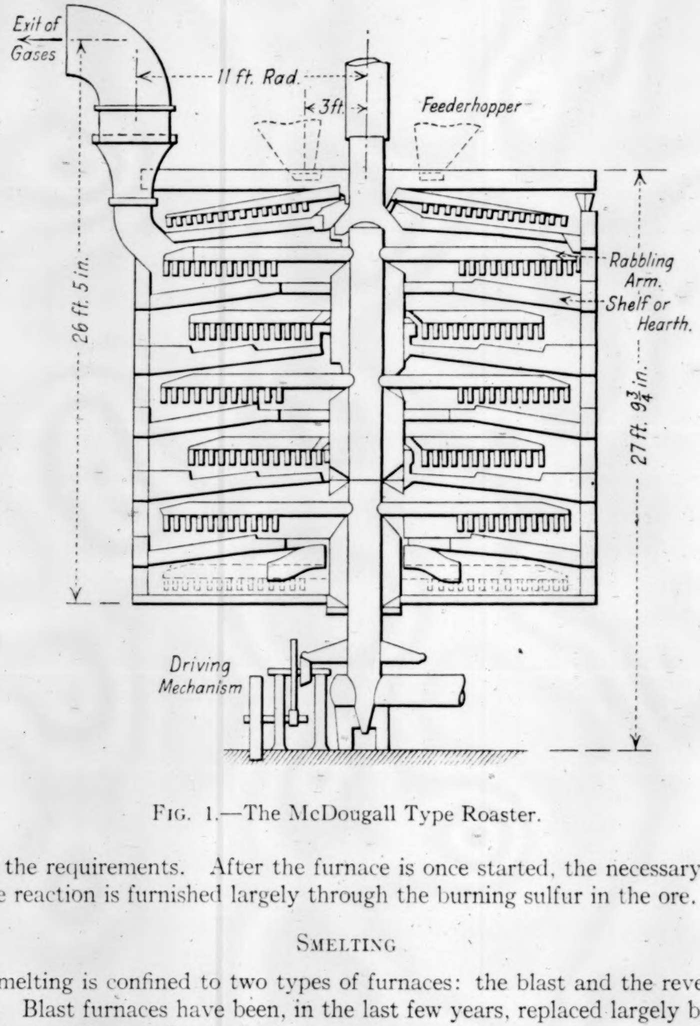

FIG. 1.—The McDougall Type Roaster.

SMELTING

Smelting is confined to two types of furnaces: the blast and the reverberatory. Blast furnaces have been, in the last few years, replaced largely by the reverberatory type and only the latter are treated here.

In smelting, attempt is not made to obtain metallic copper from the ore which has been melted, but merely to separate the copper out in the form of cuprous sulfide (Cu_2S), a material called "matte." This is accomplished by

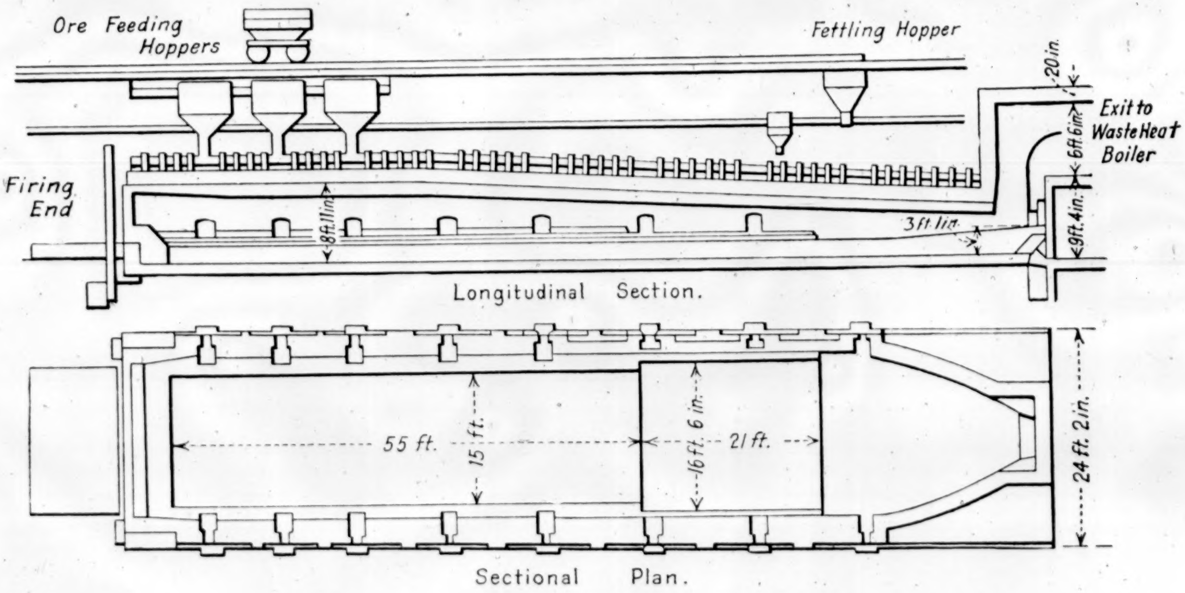
Ore Feeding Hoppers
Fettling Hopper
20 in.
Exit to Waste Heat Boiler
6 ft. 6 in.
Firing End
8 ft. 11 in.
3 ft. 1 in.
9 ft. 4 in.
Longitudinal Section.
55 ft.
15 ft.
16 ft. 6 in.
21 ft.
24 ft. 2 in.
Sectional Plan.

FIG. 2.—Reverberatory Copper Matting Furnace.

subjecting the ore to the action of heat in the reverberatory furnace, the ore being melted at the same time that the copper oxide is reduced, being dependent, as explained above, upon the weak affinity for oxygen, in comparison with iron and other base metals in the ore in the presence of a strong reducing agent.

When subjected to heat in the reverberatory furnace, the sulfur in the copper sulfide is set free and acts as a reducing agent. The resultant metallic copper has a strong affinity for sulfur, and this it obtains from the iron sulfide present in the ore. The iron is thus set free from its sulfur and upon oxidation combines with the silica of the ore to form silicates. These silicates then rise to the top and form a slag, while the heavy copper sulfide, in the form of matte, settles to the bottom. This difference in specific gravity thus permits of separation by drawing off the slag and matte separately.

In respect to the chemical action of the copper, the main reactions are reduction by sulfur and sulfurization by iron sulfide.

A typical reverberatory furnace is shown in Fig. 2. The dimensions shown are, of course, only typical, as the size of the furnace may vary from plant to plant. The fuel used may be powdered coal, coal, oil or gas. As will be noted in the figure, the roasted ore is fed through openings in the roof into the high end of the furnace by means of hoppers, the feeding holes being located along the sides of the furnace. Other feeding holes, called "fettling holes," are also provided along the sides of the furnace roof to permit of the adding of siliceous material which banks up against the side wall. This siliceous material acts as a protector or wall and at the same time furnishes the necessary silica for slagging the impurities of the charge.

The firebox or burners (whichever is used) is installed at one end of the furnace and for fuel economy, use may be made either of the regenerative principle or by utilizing the gases in waste-heat boilers. The temperatures reached in the furnace proper range from 2500 to 2800° F. (1370 to 1540° C.).

Reverberatory Furnace Bottom.—The furnace conditions demand that the bottom be refractory, strong and dense. The practice is, generally speaking, to make the bottom of a rammed-in sand, which is fitted in place to form a single block. In some cases, silica brick have been used, and in other cases chrome and magnesite have been tried out, but silica still retains the lead.

Side Walls.—Side walls are commonly of silica brick and they must resist effect of heat and slag. As mentioned previously, the temperature runs about 2800° F. (1540° C.), and in respect to the slag action, the side walls are protected by adding a siliceous material along the side wall.

Roof.—Silica refractories are the universal roof material, due in a great measure to the fact that the arch is radial and that silica forms an excellent radial arch material, because of the fact that it expands upon heating and keeps the construction tight. The arch must withstand high temperatures and some slagging action from the gases, as well as from bases from the charge that are picked up by the gases. Abrasion, of course, must be considered also. The ultimate failure of the arch has, in a number of cases, been noted to be due in a large measure to actual fusion. The reported life of a silica roof, in the hottest part of the furnace, namely, that portion extending from about 5 ft. to 35 or 40 ft. from the firing end, ranges from 3 to 6 months.

CONVERSION OF COPPER MATTE (Cu_2S) INTO METALLIC COPPER

The next process in the production of metallic copper is to separate the copper matte obtained from the reverberatory furnace from its sulfur, as well as from some impurities which it carries with it. This conversion is commonly done in an apparatus called a converter. In this process, air is forced through the matte at a temperature of about 2150 to 2200° F. (1175 to 1205° C.). Silica is also present in the charge for the purpose of slagging such iron as may be present. The air forced through the molten bath oxidizes the iron which combines with the silica to form a slag. The sulfur of the matte joins with the oxygen of the air to form sulfur dioxide, which passes off as a gas. The metallic copper is thus set free.

The oxidation of the iron and sulfur and the union of iron oxide and silica furnishes the necessary heat for the operation.

Figure 3 shows the general typical converter design. There are, of course, several types of converters—horizontal, vertical, barrel, and ball shape—but the principle of operation of all is the same and this particular figure will serve to give an idea of design and operation. The operation of the converter is periodic, taking about 60 to 90 minutes to convert the charge, at the end of which time the temperature drops to 1200 to 1500° F. (650 to 815° C.) during the discharging and recharging. The temperature reached in the operation is not much above 2200° F. (1205° C.), especially in the basic process. There is thus some temperature fluctuation and this is more evident in what we might term the upper half of the matte than in the lower half, as the lower half of the furnace is protected to a greater extent by the charge. The blowing action of the air through the tuyeres and up through the charge has a cooling as well as an abrasive effect on the upper portion of the furnace. The refractory demand of the lining is, therefore, not particularly severe, but it must withstand some abrasive and spalling action, as well as have resistance to slagging action. The operation of the converter is termed either acid or basic, depending upon the character of the lining, but the operation itself is the same.

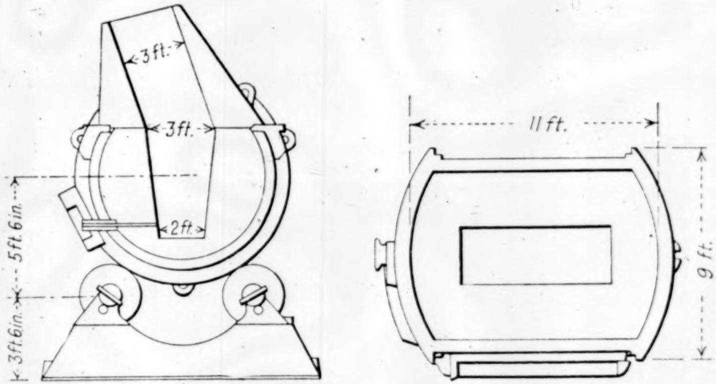

FIG. 3.—Horizontal Type Copper Converter.

In the acid converter the lining consists of a rammed-in silica ganister and requires that the lining be replaced rather often. This type of lining is fast being displaced, however, in the so-called basic process, in which the lining is not attacked. Magnesite, of course, is the refractory used in this case. The silica necessary for slagging the iron oxide is supplied by the siliceous ore charged. What might be termed the upper half of the furnace lining requires repairing every six months, while the lower portion of the lining has lasted upwards of four years.

REFINING

Blister copper, resulting from the process of converting, receives its name from the cavities or roughness caused by dissolved SO_2 being given off when the metal is solidifying. Blister copper, while containing from 97 to 99 per cent of copper, still retains impurities such as iron, lead, zinc, cobalt, nickel, arsenic, antimony, bismuth, sulfur, silver, gold, copper oxide and gases, which make it unfit for industrial use and it must, therefore, be further refined. The refining process is not commonly carried out at the point of production of blister or impure copper but is largely done at points near the large consuming centers.

Chemistry of the Process:

The refining process is carried out in reverberatory furnaces, and consists in an oxidizing fusion (charge melted with excess air) followed by a reducing fusion (melted charge subjected to limited air supply and a reducing agent such as carbon).

In an oxidizing fusion the contaminating metals, iron, manganese, etc., having a greater affinity for oxygen than copper are converted to the oxides of these metals, which being insoluble in copper and of a lower specific gravity than copper, float on the surface of the bath and may be skimmed off. In this oxidizing fusion, some metals such as zinc, and lead are volatilized and some copper is also oxidized to Cu_2O. It is necessary that some copper be oxidized to insure the oxidization of all foreign metals and the bath at the end of the oxidizing fusion contains about 6 per cent of Cu_2O in solution. The temperature is kept high during the first stage of the oxidizing fusion, as the impurities will more readily combine with oxygen at high temperatures than will copper. There will still be some trace of impurities in the bath, however, which will not have come in contact with oxygen during the high-temperature stage, and this remaining impurity is oxidized by first forming copper oxide which is taken into solution and thus comes into intimate contact with the impurities—the latter robbing the copper of its oxygen and being converted to the oxide rises to the surface. This last stage of the refining—that is, the formation of Cu_2O and subsequent oxidization of remaining impurities—is carried out under somewhat reduced temperatures as Cu_2O forms more readily under slightly lower temperatures. The oxidation is often hastened by forcing compressed air into the bath by means of iron pipes. The pipes burn off and the oxidized iron goes into the slag. In the oxidizing fusion, as has been described, the impurities have been removed (with the possible exception of some sulfur dioxide held in solution).

The next stage in the process is the reducing fusion, the object of which is to relieve the copper oxide, that has been formed, of its oxygen and convert it into metallic copper. The metal bath is skimmed clean, the air supply cut down and poles of wood are thrust through the skimming door into the molten bath. Water vapor in the wood, set free by the heat of the metal, stirs the copper and allows the gases (CO, H, and C_xH_y) given off by the burning wood to become disseminated through it. C_xH_y is, in this process, also decomposed into carbon and hydrogen. The resulting gases, CO and H, as well as the carbon, having a stronger affinity for oxygen than Cu_2O rob the latter and CO_2, H_2O and Cu are formed, the gases, of course, passing off, leaving a molten bath of almost pure copper.

Type of Furnaces:

In the discussion above, it is inferred that both the oxidizing and reducing fusion are carried out in one furnace practically as one process. This method is followed in a number of cases, while in other cases the metal is cast after the oxidizing fusion and the reducing fusion is carried out in another set of furnaces. It is said that a better grade of copper is produced by keeping the two processes separate. One advantage gained is that when the metal is cast, after the first process, any SO_2 held in solution will be expelled as the metal cools, SO_2 being insoluble in solidified copper. The furnaces used for treating the blister copper are spoken of as "anode" furnaces. They derive their name from the fact that the copper is cast into suitable sheets or shapes to form the anode of the electrolytic refining process to which the copper is further subjected.

In the electrolytic refining process, the copper from the "anode" is carried through the acid bath of the tank by means of electrolytic action and deposited upon the other terminal or "cathode." No refractories are used in this process, so it will not be necessary to treat the subject other than to show its general relation to the types of furnaces used for refining the metal. In the electrolytic process, copper of still further purity is produced at the cathode and impurities are deposited on the bottom of the tank, these impurities containing some of the precious metals, silver and gold, as well as some copper, and the deposition is spoken of as "Anode Mud." This mud is screened and refined in a special furnace, which will be referred to later.

The concluding process in the furnace refining of copper is the melting and fire refining of the cathode copper in the "Cathode Furnace" (also spoken of as the "wire bar furnace" and the "Market Refining Furnace," as it produces copper ready for the market, one object in this process being to melt the copper so that it may be cast into suitable forms ready for sale). The three chief types of furnaces mentioned in the refining of copper are all of the reverberatory type. They may be directly fired with coal, powdered coal, gas or oil or they may be of the regenerative or the waste-heat type (usually the latter), the waste gases being passed through the boiler setting for the production of power.

Anode Furnace:

Although in the great majority of cases, blister copper is the raw material, some plants refine black copper (of lower grade than blister copper, analyzing about 96 per cent of copper, which comes from Arizona, and is a blast furnace product) or liquid converter copper. The latter, of course, is of the same grade as blister copper, the only difference being that the molten metal from the converter is charged direct to the refining furnace instead of being allowed to cool into pigs or blister copper. Obviously the refining furnace in this case is located at the smelter works proper, the chief example of this being perhaps the Great Falls, Montana, Works of the Anaconda Copper Mining Co.

The process for treating "blister," "black," or "liquid converter" is essentially the same, although the latter two cases require more extended treatment. In the case of "black" copper, a greater amount of corrosive basic slag will be formed due to the greater amount of impurities, and in the case of the "liquid

TABLE I.—CLASSIFICATION OF REFRACTORIES FOR COPPER INDUSTRY.

	Furnace Part	Material	Temperature	Load	Spalling	Slagging Action	Abrasion	Remarks
				ROASTING PROCESS				
Roasting furnace.	Lining.	Second and third quality fire clay, red brick; cement.	1500° F. (815° C.) max.	Moderate.	Slight.	None.	Important.	
	Shelves.	Same as above.	1500° F. (815° C.) max.	Unimportant.	Slight.	None.	Important.	
				SMELTING PROCESS				
Smelting furnace, reverberatory.	Side walls.	Silica brick.	2800° F. (1540° C.) max.	Max. 15 lb. per sq. in.	Slight.	Severe.	Moderate.	
	Bottom.	Silica sand, silica brick, magnesite, chrome; silica sand largely used.	2500–2800° F. (1370–1540° C.)	Unimportant.	Unimportant.	Severe.	Moderate.	
	Roof.	Silica brick.	2800° F. (1540° C.) max.	Arch stresses.	Usually slight, although may be cause for premature failure.	Important.	Moderate.	
	Firebox.	Fire clay brick, silica brick.	2850° F. (1565° C.) max.	Max. 10 lb. per sq. in.	Moderate.	Important.	Moderate.	Conditions for direct coal fired where gas, oil, or powdered coal is used, combustion takes place in furnace proper.
	Exhaust end or bulkhead.	Silica brick.	2400° F. (1315° C.) max.	Max. 10–15 lb. per sq. in.	Slight.	Severe.	Moderate.	
	Regenerator chamber and checkers.	Fire clay brick, silica brick.	2200° F. (1205° C.) max.	Max. 10–15 lb. per sq. in.	Moderate.	Important.	Moderate.	Regenerators not largely used.
	Waste-heat boilers.	Fire clay brick, silica brick.	2300° F. (1260° C.) max.	Max. 15–20 lb. per sq. in.	Slight.	Important.	Moderate.	Waste heat boilers commonly used.

TABLE I.—CLASSIFICATION OF REFRACTORIES FOR COPPER INDUSTRY—*Continued.*

	Furnace Part	Material	Temperature	Load	Spalling	Slagging Action	Abrasion	Remarks
				CONVERTING PROCESS				
Converter	Lining.	Rammed clay silica for acid process, magnesite for basic.	2200° F. (1205° C.) max.	Unimportant.	Temperature drops to 1200° F. during charging. Spalling unimportant for bottom half of lining; moderate for upper half.	Severe on silica lining; moderate on basic lining.	Moderate.	Basic linings are largely used. These last as long as 4 years in the bottom half of the converter and about 6 months in the upper half
				REFINING PROCESS				
Refining furnace	Furnace roof.		2800° F. (1540° C.)	High.	Moderate to severe.	Moderate to severe.	Slight.	
	Furnace bottom.		2300° F. (1260° C.)	High.	Slight.	Moderate.	Severe.	
	Furnace side walls.	slag line.	2700–2800° F. (1480–1540° C.)	Moderate.	Moderate.	Severe.	High at charging doors.	
		upper.		Moderate.	Moderate.	Moderate to severe.	Slight.	
	Combustion chamber.		2800° F. (1540° C.)	Moderate.	Moderate.	Varies with fuel.	Varies with fuel.	
	Exit flues.		2800° F. (1540° C.)	Moderate.	Moderate.	Severe at intake.	Moderate.	
	Waste-heat boilers.		2700–2800° F. (1480–1540° C.)	Moderate.	Moderate.	Moderate.	Slight.	

converter" product, an operation called "dense poling" is necessary to expel the dissolved SO_2 which is otherwise normally removed in the cooling process in making "blister" copper as explained above. The "dense poling" operation is much the same as the poling operation referred to under "Oxidizing Fusion," wooden poles being inserted into the bath—the burning of which furnish CO, C and H for reducing the Cu_2O.

In regard to the size of the furnaces, if the copper is of low grade (such as "black" copper) and require a prolonged refining operation, the furnace size is limited to about 20 tons capacity, while those treating the purer converter or blister copper may run up to 250 tons capacity.

Operation is divided into charging, melting, fining (rabbling), poling and casting. The actual charging consumes from one to three hours, depending upon the size of the furnace. In large furnaces it is common practice to put in about three-fourths of the charge, melt this down in about four hours and then add the balance of the charge. After the charge is placed, the side doors are closed and luted, and the temperature brought up to about 2800° F. (1538° C.) at the end of three to four hours. About eight to twelve hours is consumed in melting or fusing all the copper.

The fining or rabbling process is then begun and consumes from two to six hours. This process has been described above, relating to the oxidizing fusion. This is followed by the "poling" or reducing fusion, also described above, which consumes from one to two hours.

The drawing or casting process is done at the rate of about 50 tons per hour and for a 200-ton furnace the total time would be around four hours.

The chief temperature fluctuations occur, therefore, from drawing to charging and melting, the temperature fluctuating from practically atmospheric to 2800° F. (1538° C.).

Furnace Bottom Construction.—The bottom is commonly built up with sand, burnt in. Silica brick have been used in some limited cases to replace sand. The bottom is also often air cooled to prevent it from becoming too hot and breaking out. The chief difficulty is to make the bottom sufficiently strong so that it will not come up. In reference to sand bottom *versus* silica brick, the sand bottom absorbs more copper than does one built of brick. Magnesite brick have also been used in constructing bottoms. The average life of bottoms in one case, constructed from sand, is reported as two years. Magnesite bottoms are generally used only where the charge is very impure.

Side Walls.—The upper side walls are commonly constructed from silica brick with magnesite along the slag line. Magnesite and chrome have been used, in some cases, for the entire side wall. Clay brick have also been used to some extent in upper side walls. The life on lower side walls has been reported as being equal to two to three roofs; around the charging doors, and for magnesite wall at the slag line with patching, the average is one year.

The upper side wall life in a particular case of silica brick is 40 to 60 days before patching is necessary. The chief cause of failure is the splattering up of the copper during the blowing operation—the copper becomes oxidized as it comes in contact with the air and thus tends to form copper silicate when it comes in contact with the brick. A dense brick from this standpoint, therefore, seems to give better results.

Roof.—The roof is in practically all cases made from silica. Fire-clay brick are reported to have been tried out with success in one or two cases.

A 12-in. special roof of silica has given an average life of six months. The most severe spot is over the air pipes (used in oxidation). Patching is necessary from 45 to 60 days. The chief spalling trouble that occurs takes place the first two or three days. The chief cause of failure here, as in the case of the side walls, is the corroding action of Cu_2O caused by splattering.

Other Uses.—The combustion chamber of the furnace is commonly constructed from high-grade fire-clay brick, fire-clay brick also being used in the exit gas flues that lead to the waste-heat boilers. A life of two months to one year for fire-clay brick has been reported in the combustion chamber and four to ten weeks for those in the most severe spot in the exit flues. In the latter case, at the immediate uptake, the brick are, of course, subjected to the corrosive action of the basic slags carried in the gases.

Fire-clay brick are also used in the waste-heat boiler construction. These brick are subjected, as in the case of the flue brick, to slagging action from the furnace. The average life obtained is about one to two years.

Cathode and Anode Mud Furnaces:

As far as the design, operation, and service conditions on refractories are concerned, we may consider the "cathode" furnace to be the same as the anode furnace. The "Anode Mud" furnace also operates on the same principle. It is generally, however, quite small and very few refractories are consumed in this work. This furnace, of course, treats rather impure material and for that reason chrome or magnesite are used in the bottom. This furnace is also spoken of as the "Del Ray" furnace.

The accompanying table is given to portray the refractory service conditions in the various portions of the furnaces used in roasting, smelting, converting and refining.

OTHER USES OF REFRACTORIES IN THE COPPER INDUSTRY

In addition to the uses of refractories in the processes described above, one process remains to be covered, the smelting of native copper ore. This phase is still to be investigated.

APPENDIX III

INDUSTRIAL SURVEY OF CONDITIONS SURROUNDING REFRACTORY SERVICE IN THE LEAD INDUSTRY

The common occurrence of lead is as a sulfide or galena (PbS). Before being treated for metal extraction or smelting, the ore is first roasted, that is, the sulfur is driven off and the lead converted to an oxide. In all modern plants, mechanical roasters are used in which refractories do not play any part. We can, therefore, deal at once with the smelting operation. Smelting is done in reverberatory furnaces, ore hearths and blast furnaces. The latter two are the ones commonly used.

LEAD SMELTING

Smelting Lead in Blast Furnaces.—The object of smelting is to slag off the impurities contained in the ore and to obtain a separation of metallic lead from the charge. Slagging agents, such as iron ore, limestone and sandstone, are added to the charge, as the impurities contained in the lead ore itself are not of the correct proportions to form a free-running slag, nor one which has a specific gravity such as will promote distinct separation of the slag, matte and molten metallic lead.

A typical slag desired would consist of calcium oxide, iron and silica. Coke is also added to the charge in an amount of 12 to 15 per cent in order to furnish heat and to take part in the reactions taking place, which are reduction and precipitation.

The blast furnace (Fig. 1) consists of four distinct zones, reading from the top downward.

1. *Zone of Preparatory Heating* (Temperature from 212 to 752° F. (100 to 400° C.)).—The general reaction in this zone is driving off the hygroscopic water.
2. *Upper Zone of Reduction* (Temperature from 750 to 1300° F. (400 to 705° C.)).—The decomposition of hydrates continues, the dissociation of carbonates and of some sulfates begins. Carbon begins to act as a reducing agent in reducing the lead oxide to lead. It also starts the reduction of Fe_2O_3.
3. *Lower Zone of Reduction* (Temperature from 1300 to 1650° F. (705 to 900° C.)).—The reactions started in the preceding zone continues and are in part completed. The union of silica, iron and lead to form matte begins and everything is prepared to be liquified and to bring to completion the chemical processes.
4. *Zone of Fusion* (Temperature from 1650 to 2200° F. (900 to 1205° C.)).—The reduction of the oxides are completed and lead, which has been reduced in the upper parts of the furnace, becomes melted and drips into the charge, picking up some silver on its way.

The sulfides become softened and form matte with a melting point lying below that of slag formation. The three main products, lead, matte and slag, settle in layers according to their specific gravities, the lead passing off through the leadwell; speiss, matte and slag are tapped into the fore-hearth, from which slag overflows into a waste-slag pot or granulating apparatus, and speiss and matte are tapped periodically into suitable receivers.

In regard to the refractory requirements of the lead blast furnace, it is not demanded that high-fusion brick be used for the side walls lining, as the maximum temperature reached is about 2200° F. (1205° C.). Abrasion is, of course, a considerable factor as this takes place as the charge descends in the shaft. The throat of the furnace is protected from the direct fall of the new charge by iron plates.

While, no doubt, the brick in the lower part of the shaft are affected by chemical action, experience has shown that this is not severe, as the chief melting zone is below the fire-brick lining and in that portion of the furnace covered by the water-cooled cast-iron jacket. No trouble from spalling is encountered, as the operation is practically continuous, and the load is not great.

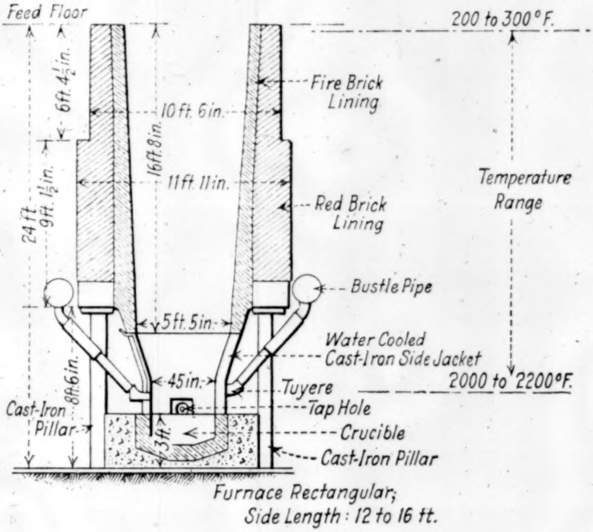
Feed Floor
200 to 300°F.
6ft. 4½in.
10 ft. 6in.
16ft. 8in.
Fire Brick Lining
24 ft.
9ft. 1½in.
11ft. 11in.
Red Brick Lining
Temperature Range
Bustle Pipe
5ft. 5in.
Water Cooled Cast-Iron Side Jacket
45in.
8ft. 6in.
Tuyere
2000 to 2200°F.
Tap Hole
Cast-Iron Pillar
3ft.
Crucible
Cast-Iron Pillar
Furnace Rectangular; Side Length: 12 to 16 ft.

FIG 1.—Lead Blast Furnace (End View).

The crucible, which is below the tuyeres in the active combustion chamber, acts as a reservoir for the molten lead and floating slag and matte. Refractoriness is not paramount as there are no temperature fluctuations, the refractory requirements being chiefly hardness and density and some resistance to the corrosive action of the lead.

In respect to life of lead blast-furnace linings, three years is reported as being very good service.

Smelting in Ore Hearths.—This method of smelting is carried on in a hearth consisting of a water-cooled cast-iron jacket, no refractories being used.

REFINING

The metallic lead obtained through smelting the lead ore may or may not be further refined or desilverized. Desilverizing is commonly accomplished by placing the lead bullion in a large kettle, heating it and adding one or two per cent of zinc, the fusion of the latter being to form an alloy with the silver, which, being less fusible than lead, and having a lower specific gravity, will become hard and float on the surface of the lead, when it can be removed and treated separately.

With respect to the use of refractories for this purpose, iron kettles are set in a sort of dutch-oven effect, by means of which the heat is supplied to the charge. The temperatures are very low and ordinary fire brick are satisfactory.

After being desilvered, the molten lead is further refined in order to remove the excess zinc.

Lead Refining Furnaces.—Refining is accomplished by flowing steam through the molten lead in the presence of heat, thus volatilizing zinc, which is also partly oxidized.

Figure 2 shows the design of a lead refining furnace. Molten lead is charged into this furnace from the desilvering kettles by being pumped through pipes. The discharging and recharging operation requires about two hours. The fire is urged for three or four hours, after which the surface of the lead will be covered with heavy litharges. The doors are thrown open to cool the surface of the metal and the skimming is removed, and the second heat given, after which cooling and skimming are repeated.

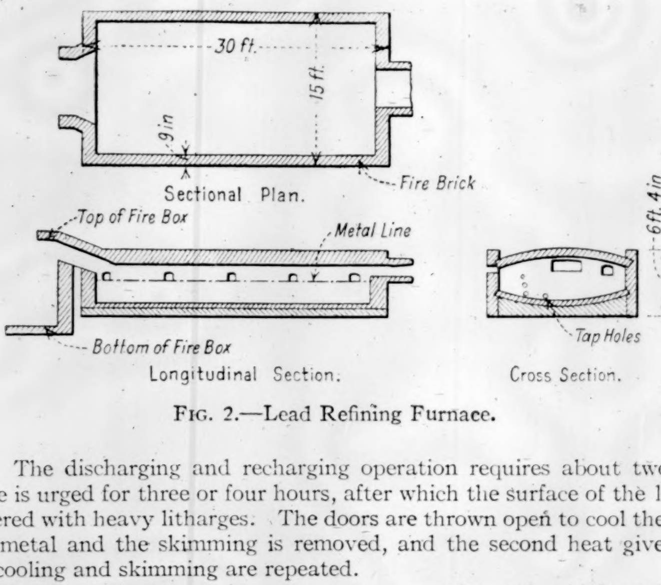

Fig. 2.—Lead Refining Furnace.

High refractoriness or resistance to temperature is not the chief requisite, the maximum temperature reached being about 2000° F. (1095° C.). While the temperature fluctuates due to the intermittent operation, the range is not such as to cause serious trouble. Some abrasion is caused by the washing of the bath against the side walls and by the paddles used in skimming off the dross. Such action is not especially severe. Slag action is the chief factor in deteriorating the refining furnace lining. This action is caused by the lead oxides, and in some cases antimony oxides, which form on the surface of the bath. These oxides have a strong affinity for silica and corrode siliceous fire-clay brick very rapidly. Magnesite and chrome brick have been used, but with varying degrees of success, the objection to the former being its high coefficient of expansion, resulting spalling tendency and the loosening of joints which permits the lead

TABLE I.—CLASSIFICATION OF REFRACTORIES FOR THE LEAD INDUSTRY.

Class	Furnace Part	Material	Temperature	Load	Spalling	Slagging Action	Abrasion	Remarks
Blast Furnace.	Lining.	Fire clay.	2200° F. (1205° C.)	15–20 lb. per sq. in. max.	None.	Not severe.	Important.	**Bottom part of furnace where highest temperature prevails is made of water-cooled cast iron. Density is main requirement of refractories.**
Refining Furnace.	Bottom.	Fire-clay, intermediate or high heat duty.	2000° F. (1095° C.)	Unimportant.	None.	Important.	Moderate.	
	Side walls and end walls above metal line.	Fire-clay; intermediate or high heat duty.	2000° F. (1095° C.)	10 lb. per sq. in.	Temperature change during charging, spalling slight.	Important.	Moderate.	
	Side walls and end walls at and below metal line.	Fire-clay, magnesite, soapstone, high-alumina refractories.	2000° F. (1095° C.)	10 lb. per sq. in. max.	Very slight.	Very important.	Moderate.	
	Roof.	Fire-clay, intermediate or high heat duty.	2000° F. (1095° C.)	Arch stresses only.	Moderate.	Important.	Very slight.	
	Refining fire furnace box.	Fire-clay, largely high heat duty.	2000° F. (1095° C.)	10–15 lb. per sq. in.	Moderate.	Moderate.	Moderate.	**Conditions in firebox chamber vary depending upon whether oil, gas or coal is used as fuel.**

to work in and eventually float out the brick. Fire brick having a high alumina content have been found to be highly satisfactory in a majority of cases, due to the density and resistance to corrosion. While it is an aluminum silicate, the alumina of the brick apparently has a greater affinity for the silica than does the lead oxide of the charge.

The refractory requirements of a lead refining furnace, at and below the metal line, are, therefore, chiefly resistance to the action of lead and antimony oxides, density and mechanical strength; other factors may be ignored. The refractory should, however, be true in dimensions in order to facilitate the laying up of a tight wall, as the molten lead would otherwise penetrate the joint, solidify during shutdowns and disrupt the construction. The upper part of the furnace above the metal line may consist of fine grade of fire brick which possess moderate resistance to spalling and resistance to the prevailing lead and fire fumes.

The life of the hearth brick varies from four to six months and the upper wall and arch brick from six months to a year. This data is rather indefinite, however, due to lack of data on any one grade of material, and to the variance in operation. The nature of the particular ore being used also influences the life to a great extent—a predominance of antimony being an example.

The accompanying table gives a classification of requirements for refractories for the lead industry.

APPENDIX IV

INDUSTRIAL SURVEY OF OPEN HEARTH PRACTICE

The product of the open-hearth furnace is steel ingots, that is, masses of steel cast for working hot by the hydraulic press, steam hammer or rolling mill. The steel may be either acid or basic, although only about 5 per cent of the open-hearth production is now made by the acid process. Acid steel is steel made in a furnace with a siliceous refractory hearth, while basic steel is produced on a hearth of magnesite or dolomite, usually the former. In the basic process, phosphorus is eliminated from the metal, while in the acid process it is not.

FUEL

The fuels used in open-hearth practice are the following: Producer gas; natural gas; fuel oil; tar; coke-oven gas; pulverized coal.

The most common fuel is producer gas, although within the last few years a number of large plants operated by companies which also operate by-product coke ovens have discontinued the use of producer gas for a combination of tar and coke-oven gas. Natural gas at the present time is not widely used, because of its scarcity and high cost. In some districts, as in the vicinity of St. Louis and in New England, fuel oil is the most common fuel. Tar is sometimes used alone, but generally in combination with coke-oven gas. Pulverized coal is not used to any great extent.

The kind of fuel is an important factor in the life of the refractories, not only because of the differences in design of the furnace with the different types of fuel, but also because of differences in the character and intensity of the flame. Producer gas has a comparatively long flame and for that reason, in furnaces fired with this gas, the end walls and downtakes are subjected to high temperatures and must frequently be renewed. Coke-oven gas has a less severe action on the end walls and downtakes, but it gives a high temperature and as the gas tends to travel along the roof, its use may lead to more frequent roof repairs unless this tendency is overcome by special design of the furnace.

FURNACE

Figure 1 is a sketch of an open-hearth furnace and gives the names of the furnace parts. The dimensions of open-hearth furnaces vary widely, depending upon the size and type. The size may vary from 15 to 250 ton capacity. Differences in fuel necessitate differences in dimensions. Furnaces may be either of the stationary or tilting design, and may treat all molten metal, all

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[1] In developing this survey, reference was made to the following publications:

B. M. Larsen, F. W. Schroeder, E. N. Bauer, and J. Campbell, "Service Conditions of Refractories for Open-Hearth Furnaces," *Bulletin No. 23*, Mining and Metallurgical Investigations, Carnegie Institute of Technology.

"A Study of the Open Hearth," published 1912 by Harbison-Walker Refractories Co.

"The Open Hearth," published 1920 by Wellman-Seaver-Morgan Co.

"Refractories in the Steel Industry," by J. Spotts McDowell, *Blast Furnace and Steel Plant* October–November, 1923.

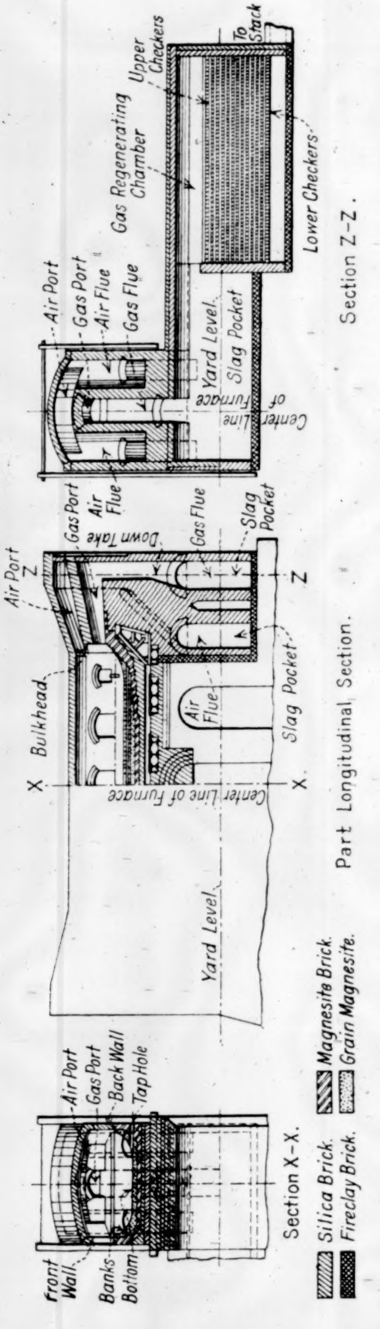
Front Wall
Banks
Bottom
Air Port
Gas Port
Back Wall
Tap Hole
Section X–X.
Silica Brick.
Fireclay Brick.
Magnesite Brick.
Grain Magnesite.
Yard Level
X
X
Center Line of Furnace
Bulkhead
Air Flue
Slag Pocket
Air Port
Z
Z
Gas Port
Down Take
Gas Flue
Slag Pocket
Part Longitudinal Section.
Air Flue
Air Port
Gas Port
Air Flue
Gas Flue
Yard Level
Slag Pocket
Center Line of Furnace
Gas Regenerating Chamber
Upper Checkers
Lower Checkers
To Stack
Section Z–Z.

FIG. 1.—Open-Hearth Furnace.

cold stock, or a mixture. The average dimensions of a 100-ton producer gas-fired stationary furnace with a basic bottom are as follows:

Length of hearth	40 ft.
Width of hearth	17 ft.
Depth of hearth	18 in.
Area of hearth per ton of capacity	10.5 sq. ft.
Gas regenerator checker dimensions	30 by 8 by 20 ft.
Gas regenerator checker volume	46 cu. ft. per ton of steel
Air regenerator checker dimensions	30 by 12 by 20 ft.
Air regenerator checker volume	68 cu. ft. per ton of steel

THE OPEN HEARTH PROCESS[1]

Open Hearth Process.—A process for the production of steel by the oxidation and removal of the impurities contained in a bath of metallic iron lying on the hearth of a regenerative furnace, the product being tapped in a fluid condition. The charge may consist of (*a*) pig iron (either solid or molten); (*b*) pig iron and scrap; or (*c*) scrap and carbon (coal and coke). There are two modifications, depending upon the nature of the lining of the furnace:

1. Acid open-hearth process, with removal of silicon, manganese, and carbon.

2. Basic open-hearth process, with removal of silicon, manganese, and carbon, as in the acid process, and in addition most of the phosphorus and often some of the sulfur.

The open-hearth furnace (see Fig. 1) is a regenerative reverberatory furnace, the name being derived from the fact that the hearth is open or exposed to the action of the flame. It should more properly be termed a Siemens furnace or Siemens regenerative furnace. The furnace comprises a hearth or sole which contains the charge, covered with an arched roof of bricks; ports or passages at each end, the air and gas for combustion entering at one end and leaving at the other; regenerators (regenerative chambers) at each end, connected with the ports by vertical flues (uptakes), and leading to the chimney or stack; at the bottom of the uptakes are small chambers or receptacles (cinder pockets, slag pockets, or dirt pockets), easily cleaned, for the purpose of catching any particles of cinder or dirt carried over, so as to protect the checkers. The hearth consists usually of metal plates lined with silica bricks, on top of which is the lining proper, consisting (*a*) for acid practice, of silica brick covered with fine sand; (*b*) for basic practice, of magnesite bricks covered with crushed dolomite, sometimes mixed with a little pitch or tar. The roof and walls above where the slag of the charge comes (slag line) are built of silica (rarely magnesite) bricks, and below this of silica (acid) or magnesite (basic) bricks, depending upon the process. Sometimes chrome (neutral) bricks are inserted between silica and magnesite bricks. The hearth is provided at the back with a tap hole, which, in the case of stationary furnaces, must be stopped up carefully with refractory material; with a tilting furnace, except when tapping, it is above the level of the bath, and so need not be closed up tightly. The hearth is usually rectangular in shape, rarely round or oval. The regenerators are the distinctive feature of the furnace and consist of fire brick flues nearly filled with bricks set on edge and arranged so as to leave a great number of small passages, known as checkers or checker work, which abstract most of the heat from the out-going waste gases and return it later to the incoming (cold) gases for combustion. If producer gas is used, both the air and gas are preheated in separate regenerators, uniting and burning only when they enter the furnace; with natural gas or petroleum, only the air is preheated.

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[1] Condensed from Tieman's Handbook for Iron and Steel (published in 1919).

Acid Open-Hearth Process.—Ordinarily the charge is composed of pig and scrap, the scrap as a rule constituting the greater part. The materials must contain less phosphorus (0.06 per cent) than is to appear in the finished steel. In some cases the scrap is charged first with the pig on top, in others this order is reversed, the object being to prevent scorification of the lining by the iron oxide formed during melting. The first stage consists in melting the materials down, during which much of the silicon, manganese, and carbon are oxidized. When completely melted, the bath should contain about 0.60 per cent of carbon, if low-carbon steel is to be made, or over 1 per cent for high carbon. To determine this, a sample is taken out in a spoon and poured into a small mold, the test ingot resulting being chilled in water and broken, its fracture giving the desired information. Frequently with high-carbon steel a quick chemical determination is also made. If the heat melts high, *i. e.*, if the carbon is still too high, ore in small amounts can be fed in (oreing or oreing down) to effect the oxidation without danger of corroding the lining, as this is not protected by the metallic bath and the slag already formed; if the heat melts low, with the danger of the bath not getting hot enough by the time the carbon is nearly all gone, pig is thrown in to supply the deficiency in carbon, and this is termed pigging, pigging back, or pigging up. The period after melting, when the carbon is being oxidized, is sometimes called the boil, and the charge is said to be on the boil. To assist in oxidizing the carbon, the bath may be stirred (shaken down) with an iron rod. In some cases steel may be obtained with a higher percentage of silicon than usual, due to a reaction or sand boil whereby silicon is reduced from the bottom or banks of the furnace.

A certain amount of heat is generated by the oxidation of the impurities, but the greater part is obtained from the combustion of the gas. Contact of the iron with the hot gases is principally brought about by the evolution of the carbon monoxide gas formed by the oxidation of the carbon in the metallic bath, which causes it to bubble and seethe; consequently it is necessary to have a certain amount of the carbon in the bath, as otherwise it will be too cold to tap. The temperature of the bath is determined partly by the eye and partly from the effect on a low-carbon iron bar in about ten seconds. If the bar is melted off sharply the bath is sufficiently hot, while if it tapers to a point it is too cold. The direction of the air and the gas for combustion is reversed at regular intervals, about 20 minutes in duration at the beginning and 15 minutes or less toward the end of the heat. Just before tapping, a small amount of ferro-manganese is usually thrown into the furnace to hold the heat, *i. e.*, to prevent any further removal of carbon, and also to effect a partial deoxidation of the bath. There are two methods for obtaining the right carbon content: (*a*) by removing practically all the carbon and then recarburizing; (*b*) by tapping when the carbon has been reduced to the proper percentage (catching the carbon on the way down). In either case, manganese (and sometimes silicon) must be added (generally in the ladle) to remove the remaining oxide in the metal. When the bath is in the right condition as regards both composition and temperature, it is run out of the furnace (tapped) by knocking out the material in the tapping hole, if a stationary furnace, or, if a tilting furnace, by lowering the tapping hole so the metal will flow out. It is caught in a ladle, and poured into molds. Recarburization is usually performed in the ladle, but may also be done in the furnace before tapping.

Basic Open-Hearth Process.—As in the acid process, the charge usually consists of pig iron (preferably molten) and scrap (with ore and limestone in addition) but the materials are not restricted as regards the phosphorus content; the sulfur, however, should be low, as its elimination is very uncertain, and at most slight; the silicon should also be low, to avoid the use of an excessive amount of lime. Since the lining is basic, ore can be charged initially without the danger of injuring it. The actual elimination of the phosphorus is performed by the lime, usually added as limestone, but occasionally burned beforehand. With these differences, the basic process closely resembles the acid as regards melting and the preparation of the bath. The proportion of the pig is generally larger, and whenever practicable it is charged in the molten condition, as a material saving in time and cost of handling results.

Special open-hearth processes are modifications of ordinary practice designed to decrease cost, increase output, or make use of material of troublesome composition (*e. g.*, high phosphorus or high silicon).

REFRACTORIES

The kinds of refractories used are the following:

Silica brick in the roof, back wall, front wall, end walls, ports and gas arches, slag pockets and uptakes, necks and sometimes in the upper portion of the regenerators for a few courses.

Magnesite brick in the hearth and the lower courses of the side walls.

High heat duty fire-clay brick in the hearth under the magnesite brick in the slag pocket and uptakes in the neck, regenerator, and checkers.

Moderate heat duty fire-clay brick in the flue.

Moderate and low heat duty fire-clay brick in the gas mains, flues and stacks.

Chrome brick between the clay and magnesite brick in the hearth, in various combinations with silica and magnesite, or alone, in the side and end walls.

Lump chrome ore is sometimes used in side and end walls.

Dead-burned magnesite in the hearth. Raw, burned, and clinkered dolomite is used for patching. Chrome ore is also used for patching and daubing.

Number of Brick.—The number of brick required for open-hearth furnaces is shown on pages 125 to 127 of the Wellman-Seaver-Morgan book. For a 50-ton basic open-hearth furnace, approximately the following amounts of refractory material are required:

Silica brick	175 000	9 in. equiv.
High heat duty fire-clay brick	250 000	9 in. "
Magnesite brick	20 000	9 in. "
Moderate heat duty fire-clay brick	50 000	9 in. "
Dead-burned magnesite	75 tons	
Chrome		
Sintered Dolomite		

TEMPERATURE RANGE

Heating.—When a furnace is entirely cold, it is considered good practice to take about four days to bring it to operating temperature. On a repair

TABLE I.—ANALYSIS OF SERVICE CONDITIONS IN PRODUCER-GAS FIRED STATIONARY OPEN-HEARTH FURNACE.

Class	Furnace Part	Material	Temperature	Slagging Action	Abrasion	Load	Spalling	Remarks
	Hearth:							
	(1) Banks.	Dolomite.	Up to 3000° F. (1650° C.)	Severe.	Severe.	Unimportant	None.	Development of cracks allows infiltration of metal, causing disruption of bottom.
	(2) Bottom.	D. B. Magnesite and dolomite.	Up to 3000° F. (1650° C.)	Moderate.	Severe.	10 lb. per sq. in. max.	None.	
	Front wall.	Silica brick.	Up to 3000° F. (1650° C.)	Severe.	Unimportant.	10 lb. per sq. in.	Important.	There may be considerable spalling in roof and walls if furnace is heated too rapidly.
H-57		Chrome brick.	Down to 1200° F. (650° C.)					
H-57	Back wall.	Silica brick.	Up to 3000° F. (1650° C.)	Severe.	Severe in some furnaces.	10 lb. per sq. in. max.	Usually slight.	
		Chrome brick. Magnesite brick.	Down to 1200° F. (650° C.)					
H-63	Roof.	Silica brick.	Up to 3000° F. (1650° C.) Down to 1200° F. (650° C.)	Severe.	Unimportant	Arch stresses.	Important.	
H-57	Ports.	Silica brick.	Up to 3000° F. (1650° C.) Down to 2000° F. (1095° C.)	Severe.	Important.	Unimportant.	Usually slight.	
H-57	Bulkhead (endwall)	Silica brick. Chrome brick. Magnesite brick.	2900° F. (1595° C.) max. 2000° F. (1095° C.) min.	Severe.	Important.	10–15 lb. per sq. in. max.	Slight usually except on repairs	
H-55	Downtake.	Silica brick.	2900° F. (1595° C.) max. 2000° F. (1095° C.)	Severe.	Moderate.	15–20 lb. per sq. in. max.	Slight.	
H-55	Slag pocket.	Silica brick.	2900° F. (1595° C.) max. 2000° F. (1095° C.) min.	Severe.	Unimportant.	5–10 lb. per sq. in. max.	Unimportant.	
H-57	Upper checkers.	First quality fire-clay brick. Silica brick.	Gas: 2400° F. (1315° C.) max. 1100° F. (595° C.) min. Air: 2600° F. (1425° C.) max. 250° F. (120° C.) min.	Important at top; not important at bottom.	Slight except in upper portion.	5–15 lb. per sq. in. max.	Usually slight.	Gas checkers: Top varies from 2400 to 2000° F. (1315 to 1095° C.); bottom from 1100 to 1400° F. (595 to 760° C.). Air checkers: Top varies from 2600 to 2000° F. (1425 to 1095° C.); bottom from 250 to 1400° F. (120 to 760° C.).
M-1	Lower checkers.							
H-57	Checker chambers.	First quality fire brick.	Same as under "checkers."	Same as under "checkers."	Same as under "checkers."	10–20 lb. per sq. in. max.	Usually slight.	
M-1	Flue to stack.	Second quality fire-clay brick.	Up to 1350° F. (730° C.)	Unimportant.	Unimportant.	Unimportant.	None.	
M-1, L-1	Stack.	Second and third quality fire-clay brick.	Up to 1200° F. (650° C.) at bottom stack.	Unimportant.	Unimportant.	Unimportant because of low temperature.	None.	

to roof or walls, when the checkers have not completely cooled off, heating up is gradually done in a period of about 36 hours before charging. At some plants only about two-thirds of these times are taken.

Temperature Distribution on Inner Wall Surfaces.—Within the melting chamber, the surfaces of roof and walls all tend to approach uniformity of temperature due to radiant heat interchange back and forth between different wall areas. The range of working temperatures is controlled here at the lower limit by the minimum temperatures necessary to melt steel (about 2700° F. (1482° C.)) and at the upper limit by the fusing or "dripping" temperatures of the roof brick (about 2975–3050° F. (1635–1680° C.)). In slow working furnaces, maximum roof and wall temperatures vary around 2750–2800° F. (1510–1538° C.); in sharp working furnaces the range is 2900–2975° F. Most furnaces, however, are overheated at times and the brick surfaces reach 3000–3100° F. (1649–1705° C.), causing fusion in local areas or at times over a whole roof or wall surface. In this whole range of steel-making temperatures in the melting chamber, the oxide particles in the gases combine readily with silica in the brick bodies to form a fluid slag which soaks into the porous brick or washes their surfaces from them.

In the upper part ends the wall surfaces are usually 100–200° F. cooler than those in the melting chamber, but approach the latter in certain cases where the flame extends across the bath into the port end. Here also the oxide dusts will form a fairly liquid slag with the brick, but on lower downtake walls and in slag pockets the slag usually is cool enough to be viscous, flowing slowly down the wall surfaces. Maximum top checker temperatures vary widely in different furnaces; the range cannot be given accurately but probably is around 2300–2600° F. (1260–1427° C.). We know, however, that in "cool" checker chambers the gases deposit dust in a loosely sintered layer of fine powder, while in very hot chambers the brick often combine with the dust to form a fluid slag which runs down into the checkers, the top brick being entirely eaten away. The latter condition is rare. Every variation between these two extremes occurs in practice.

NOTE.—The roof temperature of 3275° F. (1800° C.), may be reached, but only in very extreme cases. Very serious fusing and dripping of the roof brick would certainly occur if this temperature were maintained for any appreciable length of time.

1. *Hearth.*—That there is a difference in the action upon the bottom and banks of the hearth is recognized by most furnace operators. It is the practice in some plants to use different materials in patching these parts. The banks require a material resistant to slagging action and low in price. The bottom requires a material which sinters into a dense compact mass to resist, so far as possible, the infiltration of metal. Raw, burned, and clinkered dolomite are the principal materials used for the daily patching of hearths. Major repairs are made with dead-burned magnesite.

2. *Front Wall.*—The abrasion of the side walls and roof by dust-laden gases is unimportant. These surfaces, at operating temperatures, are probably soft enough to hold most of the dust particles coming in contact with them. The action of the furnace dusts on these surfaces is essentially that of fluxing. The dust particles striking these surfaces are very small and are carried by gas currents with comparatively low velocities. The spalling action on the front wall is important due to sudden changes in temperature when the doors are opened for charging, making bottom, etc.

Silica brick is the principal material being used although a certain amount of chrome has found favor in several plants.

3. *Back Wall.*—Abrasion, or more correctly speaking, mechanical wear, is an important factor in back wall life due to the unavoidable gouging and scouring action of the charging machine. This is particularly true in furnaces charging long and unwieldy scrap but, of course, does not apply to furnaces charging large percentages of hot metal. Silica, chrome and magnesite brick and various combinations of these are used in back wall construction. Lump chrome ore has been used with some success in a few furnaces.

4. *Roof.*—Abrasion is considered unimportant for the reasons given in the discussion of front walls. Spalling is classified as "Important" because the temperature changes are quite rapid. Further, when a brick breaks, or when it spalls, the lower portion is very apt to drop out into the bath. This exposes to the furnace atmosphere the heavily fluxed middle zone of the spalled brick as well as of the four bricks which surround it. The usual result is the formation, by fusion and continued spalling, of a sizeable depression which quite frequently develops into a hole in the roof structure.

5. *Ports.*—Since the ports are really a part of the melting chamber, they would probably reach the same maximum temperature as the roof and side walls.

6. *Bulkheads* (*End Walls*).—Abrasion may possibly be an important factor here due to the changing direction of the gas stream. In very high end walls, the load may exceed 10 lb. per sq. in., particularly if chrome brick or metalkase magnesite is used.

The following series of slag analyses represent the changes in composition ot basic open-hearth slag during the process of one heat. The series were taken from stationary furnaces in two different plants employing the usual pig, scrap and ore practice:[1]

SLAG ANALYSES

Sample	Chemical Analysis, per cent							Remarks
	SiO_2	FeO	Fe_2O_3	Al_2O_3	CaO	MgO	MnO	
SERIES NO. 1								
								Charging 12.25 p. m. to 5.20 p. m.
No. 1	32.6	19.2	6.1	1.5	17.4	12.0	15.0	7.00 p. m. Not completely melted.
No. 2	32.1	12.8	3.1	4.1	23.2	13.8	13.6	8.00 p. m. Bath completely formed
No. 3	32.4	9.0	2.4	5.3	27.6	13.5	11.6	8.50 p. m.
No. 4	27.1	13.2	3.4	5.5	34.1	11.4	8.1	9.30 p. m. Lime boil starting.
No. 5	20.3	14.5	5.3	2.9	42.7	8.7	7.3	10.20 p. m. Spar addition.
No. 6	17.1	15.6	5.7	4.5	44.9	7.9	6.3	11.05 p. m.
No. 7	16.7	14.1	5.7	2.4	46.5	8.8	5.4	11.20 p. m.
								11.25 p. m. Tap.
SERIES NO. 2								
								Charging 4.30 a. m. to 8.45 a. m.
No. 1	25.1	14.3	2.4	5.7	32.2	10.4	13.2	1.00 p. m. Lime boil starting.
No. 2	14.8	20.1	5.5	5.8	38.4	8.4	7.9	2.00 p. m. Hot metal added.
No. 3	15.4	15.7	3.4	5.6	43.7	7.5	8.6	2.30 p. m.
No. 4	15.2	15.4	4.7	5.1	44.4	7.6	8.1	3.00 p. m. Hot metal added.
No. 5	13.1	17.7	5.8	3.9	44.7	7.1	8.0	4.00 p. m.
								4.15 p. m. Tap.

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[1] From a report, as yet unpublished, by the Metallurgical Section, Pittsburgh Station, U. S. Bureau of Mines.

APPENDIX V

A STUDY OF THE SPALLING TEST FOR FIRE-CLAY BRICK

By M. C. Booze[1]

The subject of spalling is an important one to everyone concerned with refractories because of the fact that this is one of the two major causes for failure in industrial furnaces, the other main cause being erosion by slags or slag-forming materials. The behavior of fire-clay brick in this respect is of particular importance because of the very wide use of this kind of refractory material, because of the differences that exist between various commercial fire-clay products in spalling tendencies, and because fire-clay brick are usually chosen for service where spalling conditions are severe.

Some confusion exists relative to the meaning of the term "spalling," and the general acceptance of a definite meaning would be of value if for no other reason than that information on this type of failure would be more definite and accurate. Technical men generally refer to spalling as breakage due entirely to thermal shock. A fairly general interpretation of the word by practical men, however, involves rupturing from any cause, and stresses the actual crumbling away more than the cause for such destruction. In the latter case, the fractures may result from bending stresses due to uneven bricklaying, from unequal shrinkage, from compression caused by thermal expansion, and from mechanical shocks as well as from abrupt temperature differences. Since these various causes of breakage require different means for correction, it is obvious that they should not all be included under one heading. It is suggested that the use of the term be confined to breakage caused by temperature differences within individual units of a furnace lining. This interpretation applies to the word as used here.

The fundamental factors involved in the spalling of fire-clay brick have been studied in two published investigations.[2] Of the controlling properties—thermal expansion, diffusivity and elasticity—the latter has been found to be the most important because it can be varied over wide limits, while the other two properties are considerably more constant in value even with products differing widely in spalling tendencies. While these data are of value in studying specific products, the determinations are too tedious for use as routine tests, and it is necessary to make use of a test which covers all of the essential properties, but which can be made with comparative ease.

The first spalling tests were made by alternately heating in a furnace and cooling in air. Occasional investigators have determined the effect of heating and cooling by noting the loss in strength after a definite number of treatments, while others have based the results upon the percentage of material lost by the test samples. The percentage loss in strength is not a good basis for judging the spalling resistance. Spalling is only important when pieces have actually fallen off and fire-clay bodies may deteriorate in strength a certain amount because of thermal stresses and then change but little upon further treatment because of an interlocking structure. It is believed that some such effect is produced by coarse, rough-surfaced grog which is frequently made use of to retard spalling. The percentage loss in weight in a spalling test is an acceptable basis for judging the results if the size and shape of the samples and the surface to be tested are all speified. With other things being equal, spalling will take place more rapidly the larger the dimensions of portion subjected to temperature stresses. In service and in all of the tests that have been advocated, only one surface of each of the individual units is directly exposed to heating and cooling action. Within reasonable limits, the depth of the piece from the heated face will have no bearing upon the portion affected by spalling, and of two pieces differing in depth, but otherwise alike, the shorter one will have the greater percentage loss when rupture occurs. If the loss were determined by volume, the depth would not be relevant, but it is more simple to determine weight loss, and standard 9 by 4½ by 2½-in. brick can always be obtained from every manufacturer.

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[1] Senior Industrial Fellow, Refractories Fellowship, Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa.

[2] F. H. Norton, "A General Theory of Spalling," *Journal*, American Ceramic Society, Vol. 8, No. 1, pp. 29–39 (1925).

M. C. Booze and S. M. Phelps, "A Study of the Factors Involved in the Spalling of Fire Clay Refractories with Some Notes on the Load and Reheating Tests and the Effect of Grind on Shrinkage," *Journal*, American Ceramic Society, Vol. 8, No. 6, pp. 361–382 (1925).

Two methods of cooling the test samples are made use of, one by air and the second by dipping in water. Air cooling is favored from the standpoint of simulating service, but requires from two to three times the number of treatments as the water dipping method for the same amount of loss and a larger amount of equipment. With air cooling, it is also more difficult to confine the cooling effect to a definite portion of the sample than with water, and the conditions are less uniform from one test to another. It is for these reasons that water dipping has come into rather general use.

The first spalling test for fire-clay brick adopted by this Society[1] involved alternately heating the ends of 9 by 4½ by 2½-in. brick at 1350° C. (2460° F.) and dipping in water to a depth of 4 in. This was later revised by requiring that the test samples be given a preliminary heat treatment at 1400° C. (2550° F.) for 5 hours before testing. This heat treatment was supposed to bring out differences in vitrification behavior between different brands of brick and since vitrification affects spalling, it was thought that the final results would be more indicative of the spalling tendencies than where the samples were not reheated. The use of this revised method for several years has brought out several objectionable features. In the first place, reheating nullifies the effect of soft burning. It is a matter of common knowledge that soft-burned brick give better service where spalling conditions are severe than hard-burned products, and the majority of manufacturers take advantage of this fact when selecting brick for such service.

The second objection is that the brick are reheated uniformly throughout and the effect of rate of vitrification is partially or wholly destroyed. In service, vitrification proceeds inward from one surface and under given conditions may take place to a greater depth with one brand of brick than another, while both may reach the same effective degree of vitrification with the reheating treatment. In service, spalling may take place without any appreciable change in the physical structure, it may occur because of the deposition of slag on one surface, or it may occur because of vitrification. Even in the latter case there are two types of spalling, one in which the fracture takes place in the vitrified portion and one in which the break occurs back of the vitrified zone and in the portion of the brick having the original structure. In the latter case and also in the first two examples cited, the original structure is certainly important and should not be altered by reheating in samples that are to be tested for such service.

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[1] Tentative Method of Test for Resistance of Fire-Clay Brick to Spalling Action (C 38 – 21 T), *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 577 (1921); also 1925 Book of A.S.T.M. Tentative Standards, p. 250.

A large number of routine tests on fire-clay brick has also shown a second serious objection to the A.S.T.M. Tentative Method for spalling. A number of brands of fire-clay brick made by one process of manufacture have been found to fail in a peculiar manner. Spalling proceeds on these in the normal manner for a few cycles, and then cracks occur near the water line which gradually become enlarged until each sample breaks into two pieces of almost equal size. There are ample service data on brick of this type to make it certain that such breakage is a peculiarity of the test rather than of the brick themselves as regards true spalling behavior.

TABLE I.—PERCENTAGE LOSS IN WEIGHT AFTER 18 HEATING AND COOLING CYCLES.

	BRAND A	BRAND B
Ends heated at 1350° C. (2460° F.), dipped in 4 in. of water	21 per cent	45 per cent
" " " " " " " 2 " " "	10.5 "	12 "
" " " " " " " 1 " " "	9 "	34 "
" " " 850° C. (1560° F.), " " 4 " " "	1 "	3 "
" " " 1480° C. (2695° F.), cooled in air blast.....	18 "	5 "

As the position of the fractures indicated that they were influenced by the depth of immersion, tests were run on two brands of brick by immersion in 1, 2 and 4 in. of water after heating the ends in the regular way at 1350° C. (2460 ° F.), by immersing in 4 in. of water after heating at 850 °C. (1560° F.) and by cooling in air after heating the ends at 1480° C. (2695° F.). These two brands were made with clays from different districts and by different processes of manufacture, but gave approximately the same service in industrial furnaces where spalling was severe. The results obtained in these tests are shown in Table I.

It will be noted that the two brands show wide divergence in the test at 1350° C. (2460° F.) when immersed in 4 in. and 1 in. of water, and also in the test where air cooling was employed. The failure of the "B" samples when dipped in 1 in. of water is similar to that found with 4-in. immersion and is a peculiarity that is difficult to explain. Subsequent tests have shown that this erratic behavior when dipped in 1 in. of water is real.

When heated at 850° C. (1560° F.) and dipped in 4 in. of water, the "B" brand brick fail more rapidly than the "A" samples, but failure takes place less rapidly on both than when heated at 1350° C. (2460° F.). One brand shows a loss of 3 per cent and the other of 1 per cent after 18 cycles. This rate of loss is too low for a laboratory test and for that reason the test at 1350° C. (2460° F.) is to be pıeferred. The samples tested after heating at 850° C. (1560° F.) do not often show cracks at the water line, but this is partially explained by the fact that they are at a comparatively low temperature, and a steep temperature gradient does not exist in the spalled portion as with those heated at 1350° C.

(2460° F.). With the lower heating temperature, it is also the case that the maximum temperature stresses during cooling are located nearer the heated end than on the samples heated at 1350° C. (2460° F.), and this further accounts for the absence of center cracks in samples tested at 850° C. (1560° F.). These cracks are shown on the "B" samples in Fig. 1. The "A" samples are of similar composition as "B," but made by a different process and show only the normal spalling on the ends as it actually occurs in service. Both of these lots of brick were tested by immersing in water to a depth of 4 in. after heating on the ends at 1350° C. (2460° F.).

In any spalling test, the cooling effect should be confined as closely as possible to a single surface. It was anticipated that immersion in water to a depth of 1 in. would give the most accurate results, but as has been stated, this procedure was less satisfactory than dipping in 2 in. of water. When air cooling is employed, the air is very apt to circulate around a considerable portion of the brick and cause cracks to appear at a greater distance from the end than should be the case. The divergent results obtained in "A" and "B" samples in the air spalling test are thought to be due in part at least to this cause.

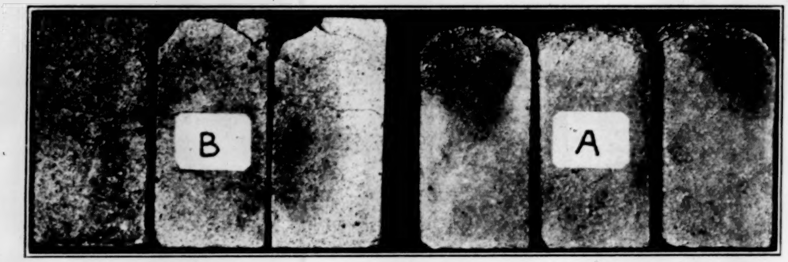

FIG. 1.—Brick Subjected to Spalling Test.

About 45 brands of brick have been tested as received by heating the ends at 1350° C. (2460° F.) for an hour, immersing in water to a depth of 2 in. for 3 minutes and returning to the furnace after steaming for 5 minutes. The results have proved to be much more satisfactory than the previously used tentative method in which reheated samples were immersed in water to a depth of 4 in. after heating the ends at 1350° C. (2460° F.). There is greater conformity between samples of one lot, more gradual spalling, greater difference between good and poor brick, and better agreement with practical results.

These items are all of considerable importance since they determine to a large degree the suitability of a laboratory test. The uniformity of results obtained on samples of one lot is especially desirable and this feature alone is sufficient to make the change in method worth while. It is admitted that the test is open to criticism even with the recommended changes, but is capable of giving information of considerable value.

REPORT OF COMMITTEE C-9

ON

CONCRETE AND CONCRETE AGGREGATES

Committee C-9 has been unfortunate during the past year in the loss of its chairman, Mr. A. T. Goldbeck, whose change of status from that of non-producer to producer has necessitated his resignation under the rules of the Society.

A new Sub-Committee, designated as XII, Editorial Committee, has been formed under the chairmanship of Mr. A. T. Goldbeck to review and edit the standards and tentative standards which have been sponsored by this committee and to recommend such changes as will improve their wording, form and arrangement. This sub-committee will review all future standards proposed by Committee C-9 before they are presented to the Society.

The sub-committee activities for the past year and their programs for the coming year are as follows:

Sub-Committee I on Definitions, L. R. Ferguson, chairman.—The definitions of the terms "sieve" and "screen," "sand," and "concrete" have been under consideration and tentative definitions drawn which are acceptable to Committee C-9 and are being reported to the Society through Committee E-8 on Nomenclature and Definitions.

Sub-Committee III on Field Tests for Concrete, E. E. Butterfield, chairman.—A series of tests of specimens cut from concrete slabs has been made and results compared with tests made on specimens molded from the same concrete in accordance with usual laboratory procedure. Other series of tests of this character are contemplated with a view to establishing more definitely the relation between the qualities of concrete in molded test specimens and similar concrete placed in structures or pavements. Some of these tests are now under way in the laboratories of the Iowa State Highway Department and of the Borough of Queens, New York City.

Sub-Committee IV on Design of Concrete, R. B. Young, chairman.—Authoritative statements have been prepared for the principal methods of design of concrete mixtures and the methods are now being compared and their limitations and fields of usefulness determined. The sub-committee has also sponsored an analytical study of the data of Series 201. Series 201 is a group of tests made for the committee by cooperating laboratories for the purpose of determining the effect of size and grading of aggregate, and of variations in the quantities of cement and water on the strength and other properties of concrete. Analysis of these tests is furnishing valuable information relative to the theories of proportioning now being reviewed by the sub-committee and will be ready to report next year.

Sub-Committee V on Specifications and Methods of Tests of Aggregates, H. F. Clemmer, chairman.—A study has been made of the Tentative Specifications for Concrete Aggregates (C 33 – 23 T)[1] and a number of changes are proposed. These changes have been considered by the main committee and after revision submitted to letter ballot. These revisions are now recommended to the Society for approval as follows:

Section 2.—Change the limits placed on material passing the No. 50 sieve from "not more than 30 per cent" to read as follows:

"Not more than	25 per cent
Not less than	5 per cent."

Immediately following the table of limits on gradation, insert the following paragraph taken from the specifications of the Federal Specifications Board:

> "If these suggested detail requirements for grading of fine aggregate cannot be met in a given locality, suitable requirements for available material should be inserted."

Add a paragraph to the section to read as follows:

> "The decantation test shall be made in accordance with the Tentative Method of Decantation Test for Sand and Other Fine Aggregates (Serial Designation: D 136 – 22 T) of The American Society for Testing Materials."

Section 8.—Add a paragraph to read as follows:

> "The method of determining the weight per cubic foot of material shall be in accordance with the Standard Method of Test for Unit Weight of Aggregate for Concrete (Serial Designation: C 29) of the American Society for Testing Materials."

Section 9.—Change the percentage passing the No. 4 sieve from 15 per cent to 10 per cent.

In the table of limits on gradation in this section, add the percentages of 40–75 for the 1-in. sieve in the case of the 2½-in. maximum size.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 626 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 209.

At the end of Paragraph (*a*) of this same section add two paragraphs to read as follows:

"The method of sampling concrete aggregates shall be in accordance with the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials (Serial Designation: D 75) of the American Society for Testing Materials."

"The sieve analysis shall be made in accordance with the Standard Methods of Test for Sieve Analysis of Aggregates for Concrete (Serial Designation: C 41) of the American Society for Testing Materials."

This revision has been submitted to letter ballot with the following results: Affirmative 34, negative 1, not voting 22.

This sub-committee is also investigating methods of tests for soundness and abrasion of aggregates, and is making a study of the effect of gradation of different aggregates upon unit weight.

Sub-Committee VI on Specifications for Concrete, Sanford E. Thompson, chairman.—This sub-committee, at its last meeting, decided that the time had arrived to proceed energetically with the development of specifications for concrete. The problems facing the sub-committee were discussed, specific work was laid out for each member, and a general procedure developed for the future. The sub-committee will meet again in June to consider material prepared by its members and hopes to have something definite to present to the Society by next year. For the present, in order to give the members of the Society as a whole a conception of the problems being worked on and, in addition, to obtain their constructive criticism, one member of the sub-committee has been selected to deliver a paper in June at the annual meeting, reviewing these problems. Although this paper will not be a sub-committee paper, it will be submitted to the sub-committee for suggestions and criticisms before being presented.

Sub-Committee IX on Admixtures, G. W. Hutchinson, chairman.—A series of tests has been completed which were undertaken with a view to developing a satisfactory method for determining the unit weight of the finely divided, and in some cases very light, materials sometimes used as admixtures in concrete. This experimental work was carried out by ten cooperating laboratories and the results are not only of value to this committee but probably will be of considerable interest to others. Some further investigations are still to be made and it is hoped that a record of the series may be presented for publication next year.

Sub-Committee X on Conditions Affecting Durability of Concrete, P. J. Freeman, chairman. Attempts are being made to determine the fundamental causes for the deterioration of concrete in service. Research is being conducted by members of the sub-committee and others on important phases of the problem, such as:

1. Porosity and permeability of concrete.
2. Changes in volume brought about by temperatures and moisture.
3. The chemical stability of concrete under different conditions.
4. The action on concrete of frost and its relation to different types of aggregates and mixtures.
5. The relation of the durability of concrete to the quality of the aggregate with which it is made.

The problems which confront the sub-committee are so intricate that progress can only be made by enlisting the cooperation of a number of qualified research organizations, and the sub-committee will endeavor during the ensuing year to enlist such help, and we welcome offers of assistance from those interested in these problems.

This report has been submitted to letter ballot of the committee, which consists of 57 members, of whom 43 have voted affirmatively, none negatively, and 14 have refrained from voting.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Acting Chairman.

J. C. PEARSON,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Specifications for Concrete Aggregates were accepted. The tentative specifications as thus revised appear on page 741.

REPORT OF COMMITTEE C-10
ON
HOLLOW MASONRY BUILDING UNITS

Committee C-10 has held three meetings during the year, has adopted amendments to one tentative standard which it is now recommending for adoption as standard, and amendments to two tentative standards which are recommended to be continued as tentative.

TENTATIVE SPECIFICATIONS AND TESTS FOR HOLLOW BURNED-CLAY LOAD-BEARING WALL TILE (C 34 - 24 T)[1]

Section 2. (*a*) *Classification.*—No changes are made in the strength and absorption values. Since there existed considerable doubt as to the strength requirements for side-construction tile, tests of the product of 57 plants were made at the U. S. Bureau of Standards according to the methods prescribed in the tentative specification, the results being shown in the accompanying Table I. All tile were 8 in. wide, 5 in. high and 12 in. long and were tested on the side, this being the position in which they are laid in the wall. It was requested that each plant send samples representative of the softest, medium and hardest tile manufactured and marketed. The resulting range in properties is probably greater than would be expected from tests of samples from a commercial shipment, and hence the classifications in the last two columns of the table are based on average strength and absorption values. Consideration of individual maximums or minimums would change the classification for the tile from nine sources. The tile graded lower on strength than on absorption in twelve cases. Most of these tile were under the standard in weight and the necessary added strength could apparently be obtained by increases in shell and web thickness. In other cases, the strength can be increased when desired by changing from the 2-cell to the 3-cell design. In eleven cases, the tile graded lower on absorption than on strength. The tile from some of these sources could probably be burned to give a somewhat lower absorption. Other tile graded as soft by absorption could receive acceptance for use in walls subject to weathering by passing the freezing test requirements of the specifications.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 818 (1924); also 1925 Book of A.S.T.M Tentative Standards, p. 217.

TABLE I.—RESULTS OF TESTS OF INDIVIDUAL UNITS OF 8 BY 5 BY 12-IN. SIDE CONSTRUCTION HOLLOW TILE.

Lot Number	Average Weight of Unit, lb.	Compressive Strength lb. per sq. in. of gross area		Absorption, per cent		Classification per A.S.T.M. Tentative Specifications C 34 – 24 T on basis of	
		Range	Average	Range	Average	Strength	Absorption
2-CELL FIRE CLAY							
1	14.4	560 to 980	820	6.5 to 7.4	6.8	Medium	Hard
2	14.8	1030 to 1700	1360	6.4 to 8.6	7.8	Hard	Hard
3	15.7	780 to 1260	1010	4.7 to 10.6	8.0	Hard	Hard
4	14.3	1090 to 1220	1150	7.4 to 9.6	8.3	Hard	Hard
5	14.7	760 to 1060	960	5.7 to 10.8	8.5	Medium	Hard
6	14.9	860 to 1620	1180	6.9 to 16.3	11.55	Hard	Hard
3-CELL FIRE CLAY							
7	14.4	690 to 1020	900	6.7 to 9.8	7.4	Medium	Hard
8	13.5	710 to 1230	1070	6.2 to 13.8	9.6	Hard	Hard
9	14.7	710 to 1620	1070	9.1 to 13.2	11.5	Hard	Hard
2-CELL SHALE							
10	16.0	560 to 1030	870	5.5 to 13.8	7.7	Medium	Hard
11	15.3	1120 to 1970	1550	3.3 to 12.6	8.4	Hard	Hard
12	15.0	390 to 1310	770	3.7 to 16.8	9.0	Medium	Hard
13	14.5	1290 to 1620	1380	8.6 to 10.9	10.1	Hard	Hard
14	15.3	600 to 1360	1040	5.3 to 14.0	10.3	Hard	Hard
15	13.9	490 to 940	750	4.4 to 16.8	10.5	Medium	Hard
16	10.3	670 to 1390	910	6.6 to 16.8	11.5	Medium	Hard
17	17.0	710 to 1500	1100	10.4 to 13.0	11.7	Hard	Hard
3-CELL SHALE							
18	15.3	570 to 880	690	11.1 to 14.8	13.4	Soft	Medium
19	16.5	790 to 2980	1550	2.7 to 15.1	9.2	Hard	Hard
20	16.0	839 to 1020	914	9.0 to 14.4	10.5	Medium	Hard
21	16.4	1000 to 3260	2040	5.9 to 16.4	11.7	Hard	Hard
22	14.5	990 to 1180	1090	9.7 to 13.5	11.8	Hard	Hard
23	15.0	690 to 750	720	1.4 to 18.1	11.9	Medium	Hard
24	15.7	570 to 1960	1110	4.3 to 19.0	12.8	Hard	Medium
25	14.6	790 to 900	845	4.6 to 21.7	14.3	Medium	Medium
26	15.6	810 to 1230	1070	13.0 to 20.6	17.1	Hard	Soft
2-CELL SURFACE CLAY							
27	15.9	1050 to 3220	1810	3.9 to 11.6	8.7	Hard	Hard
28	15.4	1230 to 1750	1410	10.5 to 12.8	11.8	Hard	Hard
29	13.8	580 to 1290	940	9.5 to 16.5	12.5	Medium	Medium
30	15.0	490 to 870	710	8.4 to 19.6	12.7	Medium	Medium
31	16.1	500 to 850	690	10.4 to 15.1	12.8	Soft	Medium
32	15.6	400 to 650	570	9.0 to 17.1	13.7	Soft	Medium
33	14.1	700 to 1140	950	12.6 to 14.9	14.1	Medium	Medium
34	12.3	230 to 950	450	8.8 to 19.8	14.2	....	Medium
35	15.0	670 to 1350	1000	10.4 to 18.2	15.3	Hard	Medium
36	16.3	900 to 1280	1040	13.9 to 16.8	15.6	Hard	Medium
37	12.3	570 to 1390	960	14.5 to 16.9	15.9	Medium	Medium
38	17.3	480 to 700	600	14.7 to 18.4	16.8	Soft	Soft
39	14.6	620 to 940	790	14.6 to 19.4	17.0	Medium	Soft
40	14.8	380 to 510	430	13.5 to 20.3	17.3	....	Soft
41	14.5	450 to 740	600	13.8 to 24.4	18.2	Soft	Soft
42	12.1	580 to 600	590	18.2	18.2	Soft	Soft
43	14.8	570 to 1330	870	17.7 to 20.1	19.3	Medium	Soft
44	13.5	380 to 840	610	17.0 to 22.2	19.9	Soft	Soft
45	13.7	410 to 670	510	22.1 to 22.4	22.3	Soft	Soft

TABLE I.—RESULT OF TESTS OF INDIVIDUAL UNITS OF 8 BY 5 BY 12-IN. SIDE CONSTRUCTION HOLLOW TILE (*Continued*).

Lot Number	Average Weight of Unit, lb.	Compressive Strength lb. per sq. in. of gross area		Absorption, per cent		Classification per A.S.T.M. Tentative Specifications C 34 - 24 T on basis of	
		Range	Average	Range	Average	Strength	Absorption
			3-CELL SURFACE CLAY				
46	17.0	2810 to 3330	3100	6.0 to 9.5	7.9	Hard	**Hard**
47	16.7	1040 to 1600	1360	7.5 to 15.4	10.8	Hard	**Hard**
48	15.9	590 to 1320	1010	9.3 to 16.5	13.1	Hard	**Medium**
49	13.9	600 to 1210	820	9.3 to 19.2	13.8	Medium	**Medium**
50	16.5	970 to 1520	1240	12.8 to 15.5	14.2	Hard	**Medium**
51	14.8	730 to 1480	1000	12.8 to 16.8	14.4	Hard	**Medium**
52	14.9	450 to 650	570	11.4 to 19.0	15.2	Soft	**Medium**
53	15.6	950 to 1240	1110	16.2 to 18.0	17.0	Hard	**Soft**
54	16.1	580 to 1030	890	16.4 to 22.0	17.6	Medium	**Soft**
55	16.7	760 to 1190	1010	22.0 to 22.9	22.3	Hard	**Soft**
56	14.9	600 to 1060	790	23.0 to 24.6	22.8	Medium	**Soft**
57	15.0	600 to 1050	770	24.1 to 26.1	25.1	Medium	**Soft**

While the tests do not indicate any need for a change in the strength and absorption requirements, a change was made in form to avoid ambiguity in classification. Thus, for the medium grade, instead of an absorption range from 12 to 16 per cent, strength on end from 1800 to 1400 lb. per sq. in. and on side from 1000 to 700 lb. per sq. in., it is changed to require absorption of 16 per cent or less, compressive strength on end of 1400 lb. per sq. in. or more and on side of 700 lb. per sq. in. or more. The proposed revised wording is as follows:

"(*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following strength and absorption requirements, both of which must be met for a given class:[1]

Class	Absorption, per cent		Compressive Strength, Based on Gross Area, lb. per sq. in.[a]			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard	12 or less	15	2000 or more	1400	1000 or more	700
Medium	16 or less	19	1400 or more	1000	700 or more	500
Soft	25 or less	28	1000 or more	700	500 or more	350

[a] Gross area shall be taken as the total area enclosed by the outside dimensions of the unit taken in a direction perpendicular to that in which the load is carried.

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[1] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification.

A new Paragraph (*c*) is proposed, to insure designs of units that will give comparable strengths in the various wall thicknesses, to read as follows:

> "(*c*) All tile shall be so designed that substantially the same masonry strength will be developed in all wall thicknesses for which they are to be used."

Section 3. (*a*) *Weights.*—The table of sizes and weights has been enlarged to include a 12 by 12 by 12-in. 9-cell unit weighing 52 lb., a 3-cell 8 by 5 by 12-in. unit weighing 16 lb., and an 8-in. 9-cell cube unit weighing 18 lb., these additions being identical with the recent changes made in the recommendations of the Division of Simplified Practice of the Department of Commerce.

Section 6. Fire Resistance.—The first sentence of this section has been revised to state definite ultimate fire resistance periods for the various wall thicknesses. These are based on fire tests of large and small walls conducted in cooperation with the Hollow Building Tile Association that are now nearly completed. The revised section is to read as follows:

> "The tile shall meet the following requirements as tested according to the Tentative Specifications for Fire Tests of Building Construction and Materials (Serial Designation: C 19 - 26 T) of the American Society for Testing Materials[1] as they apply for bearing walls and partitions and to be acceptable shall develop the following resistance periods as tested unplastered:

THICKNESS OF WALL, IN.	NUMBER OF UNITS IN WALL THICKNESS	NUMBER OF CELLS IN WALL	RESISTANCE PERIOD, HOURS[a]
8	1	2	1½
8	1	3	2
12	1	3	3
12	2	3	4
12	2	4	5
16	2 or 3	4	6

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[a] These are near the minimum values developed in tests. The average results will generally be higher. Plaster coatings ¾ in. thick applied on both sides and remaining in place throughout the fire test will increase the periods by 1 to 2 hours.

Section 8. Workmanship and Finish.—The word "anchorage" has been changed to "adhesion," the revised section reading as follows:

> "The exterior surface of all tile intended for plaster or stucco shall be scored in such a manner as to give good adhesion."

Section 11. Inspection and Rejection.—In Paragraph (*a*) the word "or" has been inserted in the second line and the wording of the last part of the sentence changed to bring out the intent more clearly. The revised section is to read as follows:

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[1] See p. 761.—ED.

"(*a*) Individual tile shall be rejected for failure to meet the weight, size or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class specified, the seller may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the seller. In case the second set of samples fails to meet the test requirements the entire lot shall be rejected."

It is proposed to omit Paragraph (*b*) providing for acceptance based on weight, absorption, fire resistance and workmanship and finish, omitting by agreement the strength tests where the tiles are used under low loads. While the tests of walls recently conducted[1] give considerable justification for such a requirement, since below a certain limit the wall strength is not greatly dependent on the strength of the individual units, it is believed desirable that strength tests be made for individual shipments whenever possible and that such tests at frequent intervals on the product from each source will be an essential help to the manufacturer in the control of plant processes.

Section 27. Absorption Tests.—The requirements for limit of sensitivity of the balance used has been changed from 0.5 per cent to 0.2 per cent, the revised section reading as follows:

"The balance used shall be sensitive to within 0.2 per cent of the weight of the smallest unit or piece tested."

Section 34. Freezing Tests.—Add a new Section 34 to read as follows:

"34. The balance shall be sensitive to within 0.1 per cent of the weight of the smallest unit or piece tested."

TENTATIVE SPECIFICATIONS AND TESTS FOR HOLLOW BURNED-CLAY FIREPROOFING, PARTITION AND FURRING TILE (C 56 – 24 T)[2]

Section 3. (a) Weights.—It is proposed to change the column heading in the table reading "Number of Cells" to "Minimum Number of Cells," to allow tile with a greater number of cells than those given in the table.

Section 5. Fire Resistance.—It is proposed to change the wording to the following, which involves no change in requirements:

"In cases where the fire resistance is an essential property the purchaser shall specify the degree of fire resistance (fire-resistance period) required, and the manufacturer shall supply such available information on the fire test performance of the given or closely similar product as will aid the purchaser in deciding whether the requirements are met. Further tests in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (Serial Designation: C 19 – 26 T) of the American Society for Testing Materials[1] may be conducted by the purchaser."

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[1] U. S. Bureau of Standards *Technologic Paper No. 311.*

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 824 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 223.

Section 7.—Change the word "anchorage" to "adhesion."

Section 10. (*a*) Insert the word "or" before "workmanship" in the first sentence of Section 10.

Change last part of the second sentence to read:

'shall be selected by the purchaser from the retained lot and tested at the expense of the seller."

Section 26.—Change the value "0.5 per cent" to read "0.2 per cent" and add the words "or piece tested."

TENTATIVE SPECIFICATIONS AND TESTS FOR HOLLOW BURNED-CLAY FLOOR TILE (C 57 – 24 T)[2]

Section 3. (*a*) *Weights.*—Change the column heading for weights of flat and segmental arch tile in the table to read "Average Weight per Square Foot of Floor, lb." In the column heading under tile for use in combination hollow tile and concrete construction change "Number of Cells" to "Minimum Number of Cells".

Section 5. Fire Resistance.—It is proposed to change the wording to the following, which involves no change in requirements:

"In cases where the fire resistance is an essential property the purchaser shall specify the degree of fire resistance (fire-resistance period) required, and the manufacturer shall supply such available information on the fire test performance of the given or closely similar product as will aid the purchaser in deciding whether the requirements are met. Further tests in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (Serial Designation: C 19 – 26 T) of the American Society for Testing Materials[1] may be conducted by the purchaser."

Section 7.—Change the word "anchorage" to "adhesion."

Section 10. (*a*)—Insert the word "or" before the word "workmanship" in the first sentence of Section 10.

Change last part of the second sentence to read:

"shall be selected by the purchaser from the retained lot and tested at the expense of the seller."

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[1] See p. 761.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 829 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 228.

Section 26.—Change the value "0.5 per cent" to "0.2 per cent" and add the words "or piece tested."

The following is the result of the letter ballot vote of the committee on the recommendations contained in this report:

Items	Affirmative	Negative	Not Voting
I. REVISED TENTATIVE STANDARD RECOMMENDED FOR ADOPTION AS STANDARD			
Tentative Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile (C 34 - 24 T)	15	0	5
II. PROPOSED REVISIONS OF EXISTING TENTATIVE STANDARDS			
Tentative Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile (C 56 - 24 T)	15	0	5
Tentative Specifications and Tests for Hollow Burned-Clay Floor Tile (C 57 - 24 T)	15	0	5

This report has been submitted to letter ballot of the committee, which consists of 20 members, of whom 15 have voted affirmatively, none negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. H. INGBERG,
Chairman.

H. D. FOSTER,
Acting Secretary.

EDITORIAL NOTE

The Tentative Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile, amended as recommended in the report, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed revisions of the Tentative Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile; and for Hollow Burned-Clay Floor Tile were accepted. The tentative specifications as thus revised appear on pages 751 and 756, respectively.

REPORT OF COMMITTEE C-11
ON
GYPSUM

During the past year, three meetings of Committee C-11 were held, one in Cleveland, Ohio, on October 27 and 28, 1925, in conjunction with other committees of the Society; one in Washington, D. C., March 12 and 13, 1926, at the Bureau of Standards; and the third in June, 1926, at Atlantic City, N. J., during the annual meeting of the Society. Each meeting was well attended and the activities of the committee during the year have been productive of much constructive work. Three new tentative specifications have been prepared during the year to meet the demands of the consumers for information relative to these products. They are Tentative Specifications for Gypsum Molding Plaster, Tentative Specifications for Gypsum Pottery Plaster and Tentative Specifications for Keene's Cement. Much investigative work was necessary in the preparation of these specifications and the United States Gypsum Co. and the U. S. Bureau of Standards cooperated in developing the essential data.

Sub-Committee I on Gypsum for Various Uses has been very active in obtaining test runs of plant size in a study of the use of anhydrite-gypsum mixes in the manufacture of portland cement. This sub-committee also sponsored work at the U. S. Bureau of Mines, Non-Metallic Minerals Station, New Brunswick, N. J., which culminated in a report by E. E. Berger, entitled "Calcium Sulfate Retarders for Portland Cement."

Sub-Committee II on Gypsum Plasters prepared the three specifications mentioned above, which are appended hereto.[1]

Sub-Committee III on Structural Gypsum Products has been quite active in developing information and data relative to size, shape and method of procuring test specimens of poured-in-place gypsum construction.

Sub-Committee IV on Testing Methods has sponsored work to determine the value of a new method for the measurement of consistency. This sub-committee also offers as an appendix to the report of the committee a paper by H. F. Gardner, chemist, Beaver Products Co., entitled "Notes on the Chemical and Microscopic Determinations of Gypsum and Anhydrite."

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[1] See pp. 745–750.—Ed.

The following recommendations are made to the Society, relative to the specifications under the jurisdiction of Committee C-11:

Standard Specifications for Gypsum Partition Tile or Block (C 52 - 25).[1]—It is recommended that the last sentence of Section 14 (*c*) be changed to read as follows by the addition of the italicized words and the omission of those in brackets:

> "When neat gypsum mortar is used for bedding and capping the test may be conducted after the mortar has set, but not sooner than [one hour] *twenty-four hours* after the sample has been capped."

Standard Specifications for Gypsum Plasters (C 28 - 21).[2]—Changes are recommended in these specifications tending to raise the quality of the products. The detailed revisions recommended for publication as tentative are as follows:

Section 3.—Change the second and third sentences of Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "The [remainder] *other 33.3 per cent* shall contain not less than [75] *60.5* per cent [of its] *by* weight of calcined gypsum *calculated from the SO_3 content.* The [other 25 per cent of this] remainder may consist of materials to control the working quality, setting time, and the fibering.[1]"

Change the second and third sentences of Paragraph (*b*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "The [remainder] *other 25 per cent* shall contain not less than [75] *60.5* per cent by weight of calcined gypsum, *calculated from the SO_3 content.* The [other 25 per cent of this] remainder may consist of materials to control the working quality, setting time, and the fibering."

Section 6.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "Gypsum neat plaster is a plastering material in which not less than [85] *60.5* per cent of the cementitious material is calcined gypsum, *calculated from the SO_3 content, and* mixed at the mill with other materials."

Section 7.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "Gypsum neat plaster shall contain not less than [85] *60.5* per cent by weight of calcined gypsum, *calculated from the SO_3 content.* The remainder may consist of materials to control the working quality, setting time, and fibering."

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[1] A.S.T.M. Standards Adopted in 1925.

[2] 1924 Book of A.S.T.M. Standards.

Section 8.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"Gypsum neat plaster *when mixed with three parts by weight of testing sand* shall set in not less than [1½] *8* hours *nor more than 32 hours*.

Section 11.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"Gypsum wood-fibered plaster shall contain not less than [80] *60.5* per cent by weight of calcined gypsum, *calculated from the* SO_3 *content* and not less than 1 per cent by weight of wood fiber made from a non-staining wood. The remainder may consist of materials to control the working quality and setting time."

Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 – 25 T).[1]—It is recommended that with the approval of Committee E-8 these definitions be advanced to standard.

Proposed New Specifications.—The following three new tentative specifications are submitted as appended hereto[2] with the recommendation they be accepted for publication as tentative:

Proposed Tentative Specifications for Gypsum Molding Plaster.

Proposed Tentative Specifications for Gypsum Pottery Plaster.

Proposed Tentative Specifications for Keene's Cement.

The addition of the following members to the committee has not disturbed the balance of producer and non-producer membership:

Rumford Chemical Works (producer), Providence, R. I., represented by Robert S. Edwards.

H. J. Brown (non-producer), Boston, Mass.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following result:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISIONS OF STANDARDS			
1. Standard Specifications for Gypsum Partition Tile or Block (C 52 – 25)	21	0	12
2. Standard Specifications for Gypsum Plasters (C 28 – 21)	24	0	9
II. TENTATIVE STANDARDS ADVANCED TO STANDARD			
3. Definitions of Terms Relating to the Gypsum Industry (C 11 – 25 T)	21	3	9
III. PROPOSED NEW TENTATIVE STANDARDS			
4. Tentative Specifications for Gypsum Molding Plaster	23	0	10
5. Tentative Specifications for Gypsum Pottery Plaster	23	0	10
6. Tentative Specifications for Keene's Cement	20	0	13

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 633 (1925); also, 1925 Book of A.S.T.M. Tentative Standards, p. 255.

[2] See pp. 745–750.—ED.

This report has been submitted to letter ballot of the committee, which consists of 33 members, of whom 26 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

WARREN E. EMLEY,
Chairman.

H. J. SCHWEIM,
Acting Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Gypsum Partition Tile or Block and for Gypsum Plasters were accepted for publication as tentative and appear on pages 1125 and 1124.

The Tentative Definitions of Terms Relating to the Gypsum Industry were amended as indicated in the Summary of the Proceedings on page 36, and 14 of the definitions as indicated in the Summary were approved and subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926. The remaining definitions were continued as tentative and appear on page 786.

The proposed Tentative Specifications for Gypsum Molding Plaster; for Gypsum Pottery Plaster; and for Keene's Cement were accepted for publication as tentative and appear on pages 745, 747 and 749, respectively.

APPENDIX

NOTES ON THE CHEMICAL AND MICROSCOPIC DETERMINATIONS OF GYPSUM AND ANHYDRITE

By H. F. Gardner[1]

While the present method of analysis of gypsum of the American Society for Testing Materials[2] is correct in most particulars, it gives no information relative to the determination of anhydrite in calcined gypsum. Also the procedure recommended for the determination of anhydrite in rock gypsum, results in high values for this material unless especial precautions are taken in the grinding of the sample. Furthermore, the tentative method for the microscopic examination of raw and calcined gypsum, proposed by Esper S. Larsen,[3] while entirely adequate from a qualitative standpoint, cannot be employed with certainty for quantitative determinations.

These two methods are those most generally employed for the estimation of anhydrite in calcined gypsum and the notes which follow, while not solving the difficulty, are offered to present the problem and indicate the inaccuracies of the above-mentioned methods.

In the present method of analysis of gypsum for the determination of free water, the sample is dried at 45° C. for two hours. However, it is the experience of the author that, if the sample is wet, drying at 45° C. for two hours does not remove all of the free water, and if the sample is practically dry to start with slight calcination will result. It is the belief of the author that the best method of drying samples for analysis or test specimens for tensile and compressive strength determinations is to dry at room temperature to constant weight at as nearly a uniform humidity as possible.

Part of the combined water in gypsum is very easily removed. In the laboratory of the Beaver Products Co., it has been found that the heat generated in ordinary grinding drives off an appreciable amount; exposure over concentrated sulfuric acid in a desiccator will remove about 2 per cent; and there are indications that the heat of the sun will completely dehydrate gypsum, as anhydrite has been found on the surface of the ground in arid desert regions.

Grinding of the sample in the manner outlined by the procedure of the American Society for Testing Materials will result in the formation of about 2 per cent of what is usually termed "soluble" anhydrite, that is colloidal particles which are completely dehydrated or small particles partially dehydrated. If this fact is not considered, the calculated results of the analysis of rock gypsum will indicate the presence of about 2 per cent more "natural" anhydrite than is actually present. Severe grinding may increase the amount of "soluble" anhydrite to 4 or 5 per cent. Several portland cement companies specify that rock gypsum shall not contain over 5 per cent "natural" anhydrite. However, their analyses invariably indicate from 2 to 3 per cent more anhydrite than found by the company supplying the rock, possibly attributable to the fact that no allowance is made for the moisture lost in grinding. In the laboratory of The Beaver Products Co. this error is corrected as follows:

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[1] Chief Chemist, Plaster Division, The Beaver Products Co., Grand Rapids, Mich.

[2] Standard Methods of Testing Gypsum and Gypsum Products (C 26 – 23), 1924 Book of A.S.T.M. Standards.

[3] E. S. Larsen, "Microscopic Examination of Raw and Calcined Gypsum," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 236 (1923).

The laboratory grinder is adjusted to a certain fineness, about 92 per cent through a No. 100 sieve. Some pure gypsum from the same deposit as the gypsum-anhydrite sample is put through the grinder, and both samples analyzed for combined water and SO_3 content. By this procedure a factor for the "soluble" anhydrite formed is obtained. Employing this factor, the amount of "soluble" anhydrite proportional to the amount of gypsum in the gypsum-anhydrite sample is deduced.

This procedure gives the amount of anhydrite to an accuracy of within 1 per cent and is considerably more accurate than any microscopic or gravimetric method. Unfortunately, however, it is not suitable for crushed rock that has been over-dried in a rotary drier, or for calcined gypsum. In rotary driers the "soluble" anhydrite or calcined gypsum may reach 8 per cent. The author has obtained very good results on a partially calcined drier sample by grinding it, mixing it to a thick paste with water, allowing to set, and air drying to a constant weight. However, this method gives results a trifle low in combined water and is excessively slow.

The determination by ordinary chemical methods of anhydrite in calcined gypsum is apparently impossible. Ordinary mill calcination to "first-settle" plaster gives an unstable product, which generally contains less than the theoretical 6.2 per cent of combined water and there is no basis whatsoever for the calculation of the "soluble" and "natural" anhydrite content.

In 1924, F. C. Welch, then at the Bureau of Standards, published a method[1] for the determination of anhydrite in calcined gypsum based upon the assumption that the hemi or half-hydrate is a stable compound and that when air, dried over sulfuric acid, is passed over the sample of calcined gypsum, the latter will come to a constant weight at supposedly the half-hydrate. In the laboratory of The Beaver Products Co., this method has been tried several times with known calcined gypsum-anhydrite mixtures with very poor results. The indications seem to be that the half-hydrate is far from a stable compound and that it cannot be determined by such a method, or for that matter by any known method. Analyses obtained by the author employing this procedure gave results far from correct and it is understood that Mr. Welch himself does not employ the method. If moist air is passed over "second settle" gypsum, or gypsum of a cook beyond "first settle," the gypsum will not stop in the absorption of moisture with the formation of hemi-hydrate. If absolutely dry air is employed, no moisture can, of course, be taken up. Authorities state that the hemi-hydrate is a compound having a definite vapor pressure. Therefore, it should be brought to a constant weight if air of a vapor pressure of the correct value is passed over it. The application of this to a practical method of analysis is as yet to be devised, so far as we know.

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[1] F. C. Welch, "Analysis of Gypsum and Gypsum Products," *Journal Industrial and Engineering Chemistry*, 1924, p. 244.

When the microscope indicates the presence of a considerable quantity of anhydrite in a calcined gypsum, one way of determining accurately the amount present is to set the plaster with water, dry to constant weight, grind the set material carefully, and analyze as indicated for rock gypsum, calculating the amount of calcined gypsum. This method is very slow and in many instances quite inaccurate, due to the fact that some calcined gypsums do not seem to take up sufficient water to form the di-hydrate. However, it does give better results than are possible by a microscopic count or a specific gravity separation, in which the liquid employed has a specific gravity between that of the calcined gypsum and the anhydrite.

Furthermore, in the determination of combined water by the present method, no account is taken of the water which may be present in certain clays or shales, some of which is liberated at the temperature (200° C.) employed. It is therefore necessary with gypsite and impure gypsums to be sure of the amount of anhydrite present, after which the SO_3 not present as anhydrite is calculated as gypsum and a report made of the amount of "excess water."

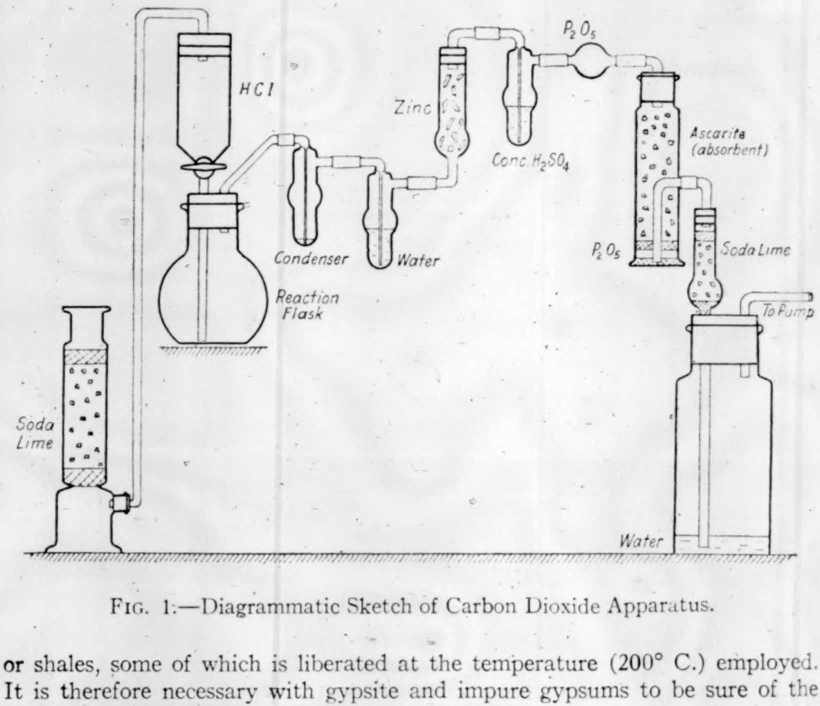

FIG. 1.—Diagrammatic Sketch of Carbon Dioxide Apparatus.

Of the many available methods for the determination of carbon dioxide, the author believes that the one devised by J. E. Underwood, of the National Lime Association, Washington, is the shortest and most accurate. Excellent results have been obtained by this method, a diagrammatic sketch of which is given in Fig. 1.

The late Dr. W. F. Hillebrand has stated, in private correspondence with the author, that the concentration of hydrochloric acid recommended in the present method of analysis for the determination of sulfur trioxide is too high. In our laboratory careful analyses of selenite and chemically pure calcium sulfate invariably give results about 0.1 per cent low for the SO_3 determination. More accurate results are obtained when less acid and less barium sulfate are employed. However, other investigators report that the present procedure gives as accurate results as with such modifications.

It has been the experience of the author that a chemical analysis, with proper precautions, gives more accurate results in the determination of anhydrite in rock gypsum than any method of microscopic counting. However, for the determination of "natural" anhydrite in calcined gypsum, recourse to a microscopic count or a gravity liquid separation only are available. The microscopic count is quite accurate when material of a size between a 200 and a 240-mesh is taken, but this size seldom approaches representing the original sample. There is a marked tendency for the harder sand and limestone to remain in the coarser screens, and for the softer gypsum to pass through the finest mesh. The procedure of the author is to make the count on material passing a 230-mesh screen and retained on a 240-mesh screen. It has been found, however, that this procedure is no more accurate than an estimation upon the original ungraded sample. By long experience and by knowing the nature of the rock and the impurities it contains, results within 5 per cent of the actual amount of anhydrite present can be obtained, but it is difficult to convince anyone not familiar with the method that such is the case.

TABLE I.—ANALYSES OF CALCULATED COMPOSITIONS AND MICROSCOPIC COUNTS ON A GYPSUM-ANHYDRITE CORE

	On No. 50 Sieve	No. 50 to 80 Sieve	No. 80 to 100 Sieve	No. 100 to 120 Sieve	No. 120 to 150 Sieve	No. 150 to 200 Sieve	No. 200 to 230 Sieve	No. 230 to 240 Sieve	Through a No. 240 Sieve	Original Sample Before Screening
SCREEN ANALYSIS, per cent	0.8	5.3	10.1	5.2	5.4	7.1	4.4	2.3	59.4	....
ANALYSIS:										
Combined Water, per cent	12.27	12.46	11.17	9.38	9.08	8.46	8.24	8.12	12.70	11.44
Carbon Dioxide (CO_2), per cent	5.23	4.08	2.51	1.90	1.41	1.28	1.16	0.98	1.04	1.85
Insoluble in HCl (1:5), per cent	0.88	0.64	0.56	0.60	0.42	0.44	0.44	0.40	0.56	0.48
Sulfur Trioxide (SO_3), per cent	44.14	45.68	48.36	50.71	51.15	52.26	52.26	52.58	49.53	49.46
CALCULATED COMPOSITION:										
Gypsum ($CaSO_4 \cdot 2H_2O$), per cent	58.7	59.6	53.5	44.9	43.4	40.5	39.4	38.8	60.8	54.7
"Soluble" Anhydrite ($CaSO_4$), per cent	1.2	1.2	1.1	0.9	0.9	0.8	0.8	0.7	1.2	1.1
"Natural" Anhydrite ($CaSO_4$), per cent	27.3	29.2	38.7	49.7	51.7	56.0	56.8	58.0	34.8	39.6
Shale, per cent	1.0	0.7	0.6	0.6	0.4	0.4	0.4	0.4	0.6	0.5
Dolomite, per cent	11.9	9.3	5.7	4.3	3.2	2.9	2.6	2.2	2.4	4.2
Total	100.1	100.0	99.6	100.4	99.6	100.6	100.0	100.1	99.8	100.1
MICROSCOPIC COUNT:										
Gypsum ($CaSO_4 \cdot 2H_2O$), per cent	8.3	10.0	8.1	39.7	42.0	42.8	40.2	37.4	56.0	52.0
Anhydrite ($CaSO_4$), per cent	4.2	13.3	17.8	41.1	45.2	49.6	54.2	59.4	41.8	44.6
Shale, per cent	1.0	1.1	0.6	0.7	0.7	0.2	0.3	0.2	0.2	0.2
Dolomite, per cent	7.0	7.8	2.4	3.2	2.0	2.4	2.2	2.4	2.0	Trace
Aggregate, per cent	79.5	67.8	71.1	15.3	10.1	5.0	3.1	0.6	....	3.2

The accompanying Tables I and II illustrate the difficulties which it has been attempted to bring out. In explanation it should be said that routine analyses were made and checked. Certain assumptions, not entirely correct, were made in reporting the calculated constituents, but it is believed that the results are accurate to within 0.5 per cent.

Table I gives the analyses, calculated compositions and microscopic counts on a gypsum-anhydrite-core sample and on this sample when ground and screened into nine different sizes. Material coarser than 150 mesh contains so much aggregate that a poor count is obtained. The best mineral separation seems to be obtained when the size of the material is between 230 and 240 mesh. The difference in chemical composition of the material of different sizes is interesting and illustrates the impossibility of obtaining accurate results employing material of the size best for mineral separation. It should also be remembered that different gypsum deposits containing different amounts of anhydrite and other impurities will, when sized, give material of entirely different compositions upon the various screens. The microscopic count upon material through a 200 and retained on a 240-mesh screen checks fairly well the chemical analysis of the same size sample, but gives results indicating much more anhydrite and much less gypsum than contained in the original sample before screening. The count upon the original sample and upon material passing a 240-mesh screen is at best only an estimation. The amount of "soluble" anhydrite was obtained by grinding a sample of pure gypsum as previously explained. The conclusion is that the analysis of a rock gypsum - anhydrite mixture is far more accurate than a microscopic count.

TABLE II.—ANALYSES OF CALCULATED COMPOSITIONS AND MICROSCOPIC COUNTS ON A GYPSUM-ANHYDRITE CORE WHEN A KNOWN AMOUNT OF ANHYDRITE WAS ADDED BEFORE CALCINATION.

Analyses of Akron, N. Y., Calcined Gypsum to Which Exactly 8.4 per cent Pure Anhydrite Was Added Before Calcination to 335° F.

Analyses made after 3 weeks' exposure in the laboratory.

	On No. 50 Sieve	No. 50 to 80 Sieve	No. 80 to 100 Sieve	No. 100 to 120 Sieve	No. 120 to 150 Sieve	No. 150 to 200 Sieve	No. 200 to 230 Sieve	No. 230 to 240 Sieve	Through a No. 240 Sieve	Original Sample Before Screening
SCREEN ANALYSIS, per cent	1.3	2.5	3.7	2.9	1.2	8.3	0.6	4.2	75.3	....
ANALYSIS:										
Combined Water, per cent	5.08	5.27	5.34	5.31	5.36	5.34	5.40	5.34	5.20	5.24
Carbon Dioxide (CO_2), per cent	5.87	5.79	4.77	4.21	3.77	3.42	3.26	2.73	3.34	3.37
Insoluble in HCl (1:5), per cent	3.78	3.94	3.58	2.80	2.92	2.44	2.32	2.32	1.84	2.42
Sulfur Trioxide (SO_3), per cent	45.93	45.80	46.56	47.84	48.26	49.41	50.13	50.19	49.86	49.49
CALCULATED COMPOSITION:										
Calcined Gypsum ($CaSO_4 \cdot \frac{1}{2}H_2O$), per cent	81.9	83.0	84.4	86.7	86.5	86.1	87.1	86.1	83.9	84.5
"Soluble" and "Natural" Anhydrite, per cent	1.3	....	....	....	1.0	3.3	3.6	4.6	6.1	4.9
Shale, per cent	4.0	4.2	3.9	3.1	3.2	2.6	2.5	2.5	2.1	2.6
Dolomite, per cent	13.3	13.1	10.8	9.6	8.6	7.8	7.4	6.2	7.6	7.6
Excess Water (H_2O), per cent	....	0.1	0.1	0.07	....	....	....	....	....	....
Total	100.5	100.4	99.2	99.5	99.3	99.8	100.6	99.4	99.7	99.6
MICROSCOPIC COUNT:										
Calcined Gypsum ($CaSO_4 \cdot \frac{1}{2}H_2O$), per cent	62.0	72.2	75.0	80.2	83.0	84.0	85.2	85.0	82.8	78.0
Natural Anhydrite ($CaSO_4$), per cent	2.0	1.6	3.2	4.8	5.0	8.2	8.4	8.8	12.2	10.2
Shale, per cent	?	?	?	10.2	12.0	6.4	6.2	5.0	...	2.6
Dolomite, per cent	?	?	?							9.2
Aggregate, per cent	36.0	26.2	21.8	4.8	....	....	....	....	....	....

Table II gives, in the same manner, the results obtained when a known amount of anhydrite was added to the gypsum before calcination. A study of this table brings out the fact that no correct idea of the amount of anhydrite in calcined gypsum can be determined by chemical analysis. The half-hydrate seems to be too unstable a compound to be used as a basis of computation, at least by any known method. As stated before, the best mineral count is obtained upon material passing a 200 and retained on a 240-mesh screen, but such a sample does not represent the original sample. It would be necessary to set, dry and analyze such a sample to obtain any results worth while.

It is believed that the above discussion indicates sufficiently the present status of the problem. It is one which should certainly interest both physical chemist and petrographer. Possibly the former could isolate the half-hydrate and the latter determine some method of sampling so that the test sample would represent the entire sample and still be of such size that an accurate count upon it could be made.

DISCUSSION

Mr. Porter. Mr. J. M. Porter[1] (*by letter*).—Concerning the method of analysis of gypsum and gypsum products developed by Mr. F. C. Welch while at the Bureau of Standards and to which reference is made in Mr. Gardner's paper on Chemical and Microscopic Determinations of Gypsum, it is not indicated by Mr. Gardner exactly why this method did not prove satisfactory. Certainly the basis upon which it is founded is sound and there is no question that the hemi-hydrate is a stable product under definite vapor pressure conditions, but it is not clearly stated in the paper that these conditions, enunciated by Mr. Welch, were those employed in the laboratory of the Beaver Products Co. In fact, reference is made only to "sulfuric acid" over which air is passed, when the strength of acid employed is a controlling factor as to whether or not the hemi-hydrate only will be formed.

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[1] Associate Chemical Engineer, U. S. Bureau of Standards, Washington, D. C.

REPORT OF COMMITTEE D-1

ON

PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS

Committee D-1 on Preservative Coatings for Structural Materials held a meeting at The Providence Biltmore, Providence, R. I., on March 18, 1926, at which thirty-two members were present. During the past year there have been five resignations, and twelve new members have been elected, making the total membership 158. As the result of a very active year, a number of new standards have been recommended, some standards revised and much work of an entirely new nature carried out.

As usual some changes in committee membership and organization have been made, one of the most significant being the large number requesting membership on Sub-Committees IX on Varnish and XXV on Cellulose Ester Coatings.

The activities of the various committees are presented in the following:

Sub-Committee III on Testing of Paint Vehicles presented a report showing results of inspection of a series of exposure tests on white paints to determine the relative dirt collection of paints of low and high pigment concentration. The report is appended hereto.

Sub-Committee V on Linseed Oil is recommending the withdrawal of the existing standard and tentative specifications for raw linseed oil as follows:

Standard Specifications for Purity of Raw Linseed Oil from North American Seed (D 1 - 15);

Tentative Specifications for Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed (D 51 - 18 T);

Tentative Specifications for Purity of Raw Linseed Oil from South American Seed (D 77 - 21 T).

The sub-committee recommends in their place new tentative specifications eliminating the geographical designation of seed origin; also changing from the Hanus to the Wijs method of obtaining the iodine value. The recommendations of the sub-committee are concurred in by Committee D-1 and are transmitted herewith as set forth in the report of the sub-committee appended hereto.

Sub-Committee VII on Accelerated Tests for Protective Coatings outlines in its report appended hereto some contemplated work on accelerated weathering tests.

Sub-Committee VIII on Methods of Analysis of Paint Materials submits recommendations to the effect that the Tentative Method of Test for Coarse Particles in Paint Pigments (D 185 - 24 T) be revised and advanced to standard; that the Parks and Van Heuckeroth Method of Test for Specific Gravity of Pigments be accepted for publication as tentative; and that the Tentative Methods of Routine Analysis of White Linseed Oil Paints (D 215 - 25 T) be continued as tentative. The proviso is made that the sieve number be inserted in parentheses immediately following the micron designation in Methods D 185. Committee D-1 approves these recommendations for reference to the Society.

Sub-Committee IX on Varnish, E. J. Cole, chairman, prepared a proposed Tentative Method for Determining Elasticity or Toughness of Varnishes of less than Zero Kauri Reduction. This is recommended for acceptance for publication as tentative as appended hereto.[1]

The principal work of Sub-Committee XI on Paint Thinners Other than Turpentine, Cloyd M. Chapman, chairman, during the past year has been the completion of Tentative Specifications for Petroleum Spirits (Mineral Spirits), which are appended to this report[2] with the recommendation that they be accepted for publication as tentative.

On the recommendation of Sub-Committee XII onTurpentine, F. P. Veitch, chairman, the present Standard Specifications for Turpentine are recommended to be withdrawn and the Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (D 13 - 26) appended hereto[3] are recommended for adoption as standard. This is in effect the advancement to standard of the revisions proposed as tentative last year but the complete revised specifications are appended for clarity. The methods of sampling and testing have been made a separate standard as an editorial rearrangement. The committee also recommends the acceptance of the appended Tentative Specifications for Destructively Distilled Wood Turpentine.[4]

Sub-committee XIII on Shellac, J. W. Paisley, chairman, recommends that the present Tentative Specifications for Dry

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[1] See p. 814.—ED.

[2] See p. 793.—ED.

[3] See A.S.T.M. Standards Adopted in 1926, pp. 62 and 76.—ED.

[4] See p. 795.—ED.

Bleached Shellac (D 207 – 25 T)[1] be advanced to standard. The sub-committee also recommends that the present Tentative Methods of Testing Shellac Varnish (D 214 – 25 T),[2] be withdrawn, as the methods have been rewritten by Messrs. Walker and Steele of the U. S. Bureau of Standards and are now presented[3] in a manner more suitable to A.S.T.M. regulations. The substance matter is practically the same as that of the present methods. The sub-committee also presents for acceptance for publication proposed Tentative Specifications for Orange Shellac.[4] Committee D-1 submits these recommendations to the Society for approval.

Sub-Committee XIV on Preparation of Iron and Steel Surfaces for Painting presents a further report appended hereto on the study it has been making on this subject.

Sub-Committee XV on Specifications for Pigments Dry and in Oil when Marketed in that Form recommends that the following specifications be revised and advanced to standard:

Tentative Specifications for Bone Black (D 210 – 25 T);
Tentative Specifications for Lithopone (D 208 – 25 T);
Tentative Specifications for Lampblack (D 209 – 25 T).

It is also recommending that the following specifications be revised and remain tentative for another year:

Tentative Specifications for Chrome Yellow (D 211 – 25 T);
Tentative Specifications for Pure Chrome Green (D 212 – 25 T);
Tentative Specifications for Reduced Chrome Green (D 213 – 25 T).

Committee D-1 approves these recommendations for submission to the Society.

Sub-Committee XVIII on Physical Properties of Paint Materials is submitting a report of a most interesting character as appended hereto.

Sub-Committee XXV on Cellulose Ester Coatings, W. R. Fuller, chairman, has effected organization during the year, whereby the work has been divided among the following six groups:

Group 1 on Soluble Nitrocellulose;
Group 2 on Solvents and Diluents;
Group 3 on Resins;
Group 4 on Plasticizers;
Group 5 on Pigments;
Group 6 on Finished Lacquers.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 644 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 282.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 660 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 298.

[3] See p. 804.—Ed.

[4] See p. 796.—Ed.

The recommendations contained in this report have been submitted to letter ballot of the committee and 53 replies have been received. The results of the letter ballot are as follows:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT OF TENTATIVE STANDARDS TO STANDARD			
Tentative Specifications for Bone Back (D 210 - 25 T)	36	0	17
Tentative Specifications for Lithopone (D 208 - 25 T)	38	0	15
Tentative Specifications for Lampblack (D 209 - 25 T)	36	0	17
Tentative Method of Test for Coarse Particles in Paint Pigments (D 185 - 24 T), as revised	42	0	11
Tentative Specifications for Dry Bleached Shellac (D 207 - 25 T)	27	0	26
II. REVISIONS OF EXISTING STANDARDS			
Standard Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine (D 13 - 24)	42	1	10
Addition of New Tentative Method for Determining Elasticity of Varnishes by Means of Addition of Linseed Oil to the Standard Methods of Testing Oleo-Resinous Varnishes (D 154 - 24)	37	1	15
III. NEW STANDARDS SUBMITTED FOR PUBLICATION AS TENTATIVE			
Specifications for Raw Linseed Oil	40	7	6
Specifications for Mineral Spirits	42	5	6
Specifications for Destructively Distilled Wood Turpentine	40	0	13
Specifications for Orange Shellac	29	0	24
Method of Test for Specific Gravity of Pigments	43	0	10
IV. REVISION OF TENTATIVE STANDARDS			
Tentative Specifications for Chrome Yellow (D 211 - 25 T)	39	0	14
Tentative Specifications for Pure Chrome Green (D 212 - 25 T)	39	0	14
Tentative Specifications for Reduced Chrome Green (D 213 - 25 T)	39	0	14
Methods of Testing Shellac Varnish (D 214 - 25 T)	32	0	21
V. WITHDRAWAL OF STANDARDS AND TENTATIVE STANDARDS			
Standard Specifications for Purity of Raw Linseed Oil from North American Seed (D 1 - 15)	41	6	6
Tentative Specifications for Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed (D 51 - 18 T)	42	5	6
Tentative Specifications for Purity of Raw Linseed Oil from South American Seed (D 77 - 21 T)	41	6	6

This report has been submitted to letter ballot of the committee, which consists of 158 members, of whom 53 have voted affirmatively, none negatively, and 105 have refrained from voting.

Respectfully submitted on behalf of the committee,

ALLEN ROGERS,
Chairman.

R. L. HALLETT,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Bone Black; for Lithopone; for Lampblack; for Dry Bleached Shellac; and Tentative Method of Test for Coarse Particles in Paint Pigments were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed revisions of the Standard Specifications for Turpentine, submitted in 1925, were amended and presented as complete new specifications under the title "Specifications for Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine." These specifications were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926. As an editorial change the methods covering the testing of turpentine were removed from the specifications and approved at the annual meeting as a separate standard. The methods were subsequently adopted as standard by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed revisions of the Standard Methods of Testing Oleo-Resinous Varnishes were accepted for publication as a new Tentative Method for Determining Elasticity or Toughness of Varnishes by Means of Addition of Linseed Oil to be added, when adopted, to the present standard methods. The method appears on page 814.

The proposed Tentative Specifications for Raw Linseed Oil were accepted for publication as tentative to supersede, when adopted, the present Standard Specifications for Purity of Raw Linseed Oil from North American Seed. On recommendation of the committee the withdrawal of the Tentative Specifications for Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed and for Purity of Raw Linseed Oil from South American Seed was approved. The new tentative specifications appear on page 788.

The proposed Tentative Specifications for Petroleum Spirits (Mineral Spirits); for Destructively Distilled Wood Turpentine; for Orange Shellac; and the Tentative Method of Test for Specific Gravity of Pigments were accepted for publication as tentative and appear on pages 793, 795, 796 and 811, respectively.

The proposed revisions of the Tentative Specifications for Chrome Yellow; for Pure Chrome Green; for Reduced Chrome Green; and of the Tentative Methods of Testing Shellac Varnish were accepted. The tentative standards in their revised form appear on pages 798, 800, 802, and 804, respectively.

REPORT OF SUB-COMMITTEE III ON TESTING OF PAINT VEHICLES

During the year 1925 the sub-committee undertook a series of exposure tests on white paints to determine the relative dirt collection of paints of low and high pigment concentration. The paints were sent to the committee members the latter part of 1924, so that exposures could be made on January 1, 1925. Full instructions regarding the tests are given in the report of the sub-committee for 1925.[1]

The paints used in the tests consisted of four groups, namely, Nos. 1, 2, 3 and 4, each of which was treated in five different reductions, reported upon as reductions *A*, *B*, *C*, *D* and *E*, the paints and reductions being as follows:

Group	No. 1.	Zinc oxide	50 per cent,	titanox	50 per cent
"	No. 2.	Zinc oxide	50 " ,	lithopone	50 "
"	No. 3.	Zinc oxide	30 " ,	titanox	70 "
"	No. 4.	Zinc oxide	50 " ,	white lead	50 "

The pigment mixtures were ground in raw linseed oil to a paste containing 80 per cent pigment and 20 per cent linseed oil by weight. These pastes were then reduced to painting consistency by adding 1 gal. of paste to the following liquids in the quantities indicated in gills ($\frac{1}{32}$ gal.).

Reduction	Raw Linseed Oil, gills	Turpentine, gills	Liquid Drier, gills	Heat-Treated Tung Oil, gills
A	14	15	3	. .
B	19	10	3	. .
C	24	5	3	. .
D	18	$3\frac{3}{4}$	$2\frac{1}{4}$	. .
E	12	$3\frac{3}{4}$	$2\frac{1}{4}$	4

The tung oil was produced by heating raw tung oil to 275° F. for a period of one and one-half hours.

At the request of one member of the sub-committee, white lead was included in the investigation, being assigned No. 5 and reduced in the following manner:

Reduction 5*A*	Reduction 5*B*	Reduction 5*C*
100 lb. paste white lead	100 lb. paste white lead	100. lb paste white lead
$3\frac{1}{4}$ gal. raw linseed oil	$4\frac{1}{4}$ gal. raw linseed oil	$5\frac{1}{4}$ gal. raw linseed oil
1 pt. drier	1 pt. drier	1 pt. drier
1 pt. turpentine	1 pt. turpentine	1 pt. turpentine

This was used by two members of the sub-committee.

In the tests made by the chairman of the committee, there were included paints 5*D* and 5*E*. Paint 5*D* was made with 40 per cent

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 227 (1925).

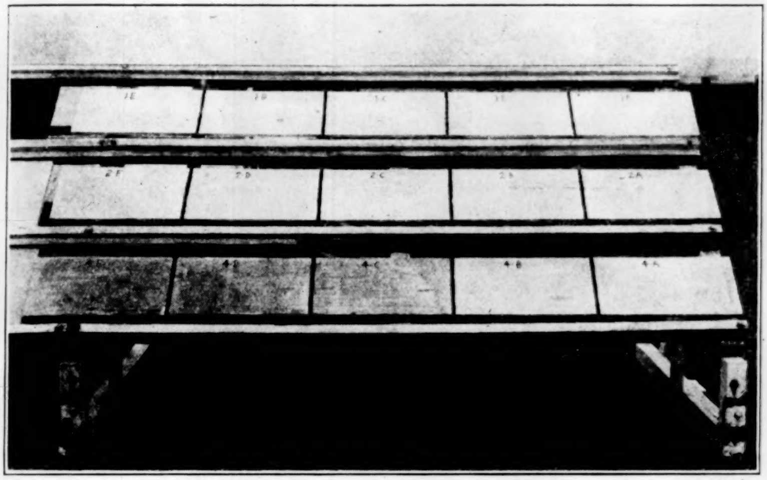

FIG. 1.—Test Rack at Kansas City, Photographed October 2, 1925.
C. R. Cook, Observer.

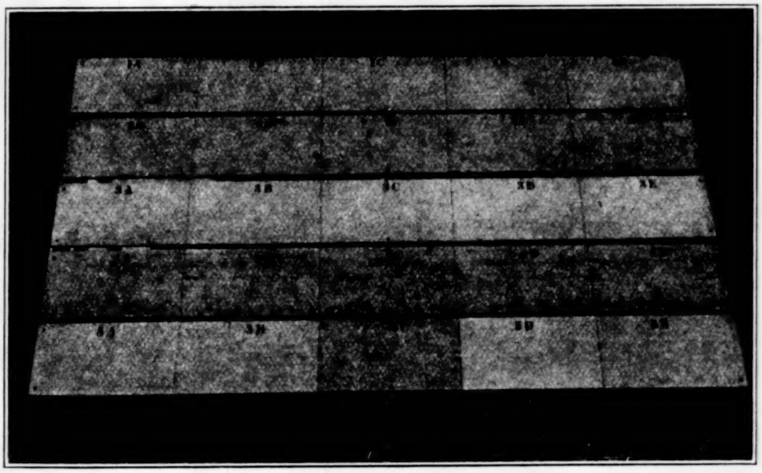

FIG. 2 —Test Rack at Washington, D. C., Photographed December 31, 1925.
H. A. Gardner, Observer.

lithopone, 40 per cent zinc oxide and 20 per cent inert pigment, ground in bodied linseed oil. Paint 5*E* was made with 35 per cent titanox, 30 per cent basic sulfate white lead, and 35 per cent zinc oxide, ground in bodied linseed oil; pigment 60 per cent and liquid 40 per cent, liquid containing 20 per cent combined thinner and drier.

RESULTS OF INSPECTION

April Inspection.—Wherever tested and reported, Group 3 presented the cleanest surface. Group 1 was placed first by two observers. Group 2 was next in order. Reductions *A* and *E* were reported as cleanest, with *E* being generally superior from this standpoint.

July Inspection.—The majority reported Group 1 as cleanest. This group was placed first by all those who did not examine Group 3 and by one observer who included Group 3. Of those four testing Group 3, two observers reported Group 3 as cleanest. Reduction *E* was reported cleanest by nearly all observers.

October Inspection.—Group 3 and Group 1 were generally reported as cleanest. Reduction *E* was reported as cleanest by most observers.

January Inspection.—Of five observers testing Group 3, two of them reported Group 3 as cleanest and three reported Group 1 as cleanest. All other five observers reported Group 1 as cleanest. Reduction *E* was reported cleanest by most observers.

Apparently Groups 1 and 3, expecially with Reductions E, gave the cleanest surfaces in these tests. A detailed summary of the reports submitted by the individual observers is given in the accompanying Table I.

At certain periods during the weathering of some paints where substantial chalking has developed, there would seem to be a direct relation between chalking and whiteness.

Respectfully submitted on behalf of the sub-committee,

HENRY A. GARDNER,
Chairman.

TABLE I.—RESULTS OF INSPECTION REPORTS BY INDIVIDUAL OBSERVERS.
INSPECTION, APRIL, 1925

Observer, Location and Groups Tested	**Cleanest**	Intermediate Ratings			**Dirtiest**	Remarks
P. R. Croll Milwaukee (Nos. 1, 2, 3 and 4)	Group No. 3. *A* and *E*, cleanest. *C*, Dirtiest.	Group No. 1. (Slightly dirtier than Group No. 3.) *A* and *E*, Cleanest. *C*, Dirtiest.	Group No. 2. (Slightly dirtier than Group No. 3.) *A* and *E*, Cleanest. *C*, Dirtiest.		Group No. 4. Uniformly dark.	Rain effect on Groups Nos. 1, 2 and 3 caused cleaner surfaces to be shown than on Group No. 4.
W. D. Jones San Francisco (Nos. 1, 2 and 4)	Group No. 4. *E*, Cleanest.					All *E* panels were whiter than others.
G. D. White Newark (Nos. 1, 2 and 4)	Group No. 1.	Group No. 2.			Group No. 4.	Panels *A* and *E* of each group were the cleanest.
P. H. Walker Washington (Nos. 1, 2, 3, 4 and 5)	Group No. 3. (Whitest, little dirt.) *A*, Cleanest.	Group No. 2. (White color, little dirt.) *A*, Cleanest.	Group No. 1. (Practically same as Group No. 4.) *A*, Cleanest.	Group No. 4. (Next worst, but fairly clean and white.)	Group No. 5. (Most dirt, and darkest.) *A*, Cleanest.	
C. R. Cook Kansas City (Nos. 1, 2 and 4)					Group No. 4.	
R. E. Rogers Pittsburgh (Nos. 1, 2, 3 and 4)	No report					
F. G. Breyer Palmerton (Nos. 1, 2 and 4)	Group No. 1. Dirt collection increases from *E* to *A*.	Group No. 2 Dirt collection increases from *E* to *A*.			Group No. 4. Dirt collection increases from *A* to *E*.	
R. L. Hallett Sayville (Nos. 1, 2, 3, 4 and 5)	(No report; did not expose panels until June 1.)					
H. A. Gardner Washington (Nos. 1, 2, 3, 4, and 5)	Group No. 3.				Group No. 5.	In all groups, panels *A* and *E* were cleaner than other panels.

TABLE I.—RESULTS OF INSPECTION REPORTS BY INDIVIDUAL OBSERVERS (*Continued*).

INSPECTION, JULY, 1925

Observer, Location and Groups Tested	**Cleanest**	Intermediate Ratings			**Dirtiest**	Remarks
P. R. Croll Milwaukee (Nos. 1, 2, 3 and 4)	Group No. 1. Shows greatest chalking.	Group No. 3. Next chalking.	Group No. 2. Next chalking.		Group No. 4. Least chalking.	In each group panel *C* was dirtiest, *B* and *D* next, and *A* and *E* cleanest.
W. D. Jones San Francisco (Nos. 1, 2 and 4)	Group No. 1. Dirt collection increases as *E*, *A*, *B*, *C* and *D*.	Group No. 2. Dirt collection increases as *E*, *A*, *B*, *C* and *D*.			Group No. 4. All panels darker than those of other groups.	1*E* and 2*E*, Cleanest panels of all.
G. D. White Newark (Nos. 1, 2 and 4)	Group No. 1. *E*, Cleanest. *A* and *B*, Dirtiest.	Group No. 2. *A* and *B*, Dirtiest.			Group No. 4. *A* and *B*, Dirtiest.	2*E* crinkled and peeled and could not be judged.
P. H. Walker Washington (Nos. 1, 2, 3, 4 and 5)	Group No. 3. *A* and *E*, Cleanest.	Group No. 1. *A* and *E*, Cleanest.	Group No. 2. *A* and *E*, Cleanest.	Group No. 4. *A* and *E*, Cleanest.	Group No. 5. *A*, Cleanest. *C*, Dirtiest.	Group No. 3 chalking quite badly, with Group 1 next.
C. R. Cook Kansas City (Nos. 1, 2 and 4)	Group No. 1. *A*, Chalking slightly. *B*, Shows indications or cracking.	Group No. 2. *A*, Badly cracked and scaling. *B*, Slight cracking.			Group No. 4. *A*, Cleanest, due to excessive chalking.	
R. E. Rogers Pittsburgh (Nos. 1, 2 and 4)	Group No. 1. Dirt collection increases as *E*, *B*, *A*, *C* and *D*.	Group No. 2. Dirt collection increases as *E*, *A*, *B*, *C* and *D*.			Group No. 4. Dirt collection increases as *E*, *B*, *C*, *A* and *D*.	1*E* and 2*E*, Cleanest panels. 4*A* and 4*D*, Dirtiest panels.
F. G. Breyer Palmerton (Nos. 1, 2 and 4)	Group No. 1. Dirt collection increases very slightly from *E* to *A*.	Group No. 2. Dirt collection increases from *E* to *A*. *A* and *B*, Much dirtier than *C*, *D* and *E*.			Group No. 4. Dirt being freed from *A* with chalking and appears cleaner. Others become darker from *B* to *E*.	Group No. 1, Heavy chalking. Group No. 2, Considerable chalking. Group No. 4, Very heavy chalking on *A*, diminishing, to slight on *E*.
R. L. Hallett Sayville (Nos. 1, 2, 3, 4 and 5)	Practically no change has occurred, except for slight loss of gloss.					Panels exposed June 1st.
H. A. Gardner Washington (Nos. 1, 2, 3, 4 and 5)	Group No. 3. Gradual whitening increases from *A* to *E*	Group No. 1. Gradual whitening increases from *A* to *E*	Group No. 4. Gradual whitening increases from *A* to *E*.	Group No. 2. Gradual whitening increases from *A* to *E*.	Group No. 5. 5*A*, *B* and *C* are especially dark and dirty. 5*A* and *B* are cleaner than 5*C*. 5*D* is very white and 5*E* is quite white	Groups Nos. 1, 3 and 4 show considerable chalking. Groups Nos. 2 and 5, Mild chalking, no definite evidences of decay.

TABLE I.—RESULTS OF INSPECTION REPORTS BY INDIVIDUAL OBSERVERS (*Continued*).

INSPECTION, OCTOBER, 1925

Observer, Location and Groups Tested	**Cleanest**	Intermediate Ratings			**Dirtiest**	Remarks
P. R. Croll Milwaukee (Nos. 1, 2, 3 and 4)	Group No. 1. Dirt collection increases as *A*, *B*, *D*, *E* and *C*.	Group No. 3. Dirt collection increases as *A*, *B*, *D*, *E* and *C*.	Group No. 2. Dirt collection increases as *E*, *A*, *B*, *C* and *D*.		Group No. 4. Dirt collection increases as *A*, *E*, *B*, *C* and *D*. *A* and *E* beginning to chalk.	**Center dirtiest, lightening toward ends. No noticeable checking or cracking on any panels.**
W. D. Jones San Francisco (Nos. 1, 2 and 4)	Group No. 1. *E*, Cleanest.	Group No. 2. *E*, Cleanest. *A*, Darkest.			Group No. 4.	Panel 1*E* cleanest of all panels.
G. D. White Newark (Nos. 1, 2 and 4)	Group No. 1. *E*, Cleanest. *A* and *B*, Dirtiest.	Group No. 2. *B*, *C* and *D*, Cleanest. *E*, Dirtiest.			Group No. 4. *A*, Cleanest. *C*, *D* and *E*, Dirtiest.	**All surfaces cracking slightly, except 2*E*, which is a mass of cracks, and 4*D*, which shows no cracking.**
P. H. Walker Washington (Nos. 1, 2, 3, 4 and 5)	**Group No. 3 and 5*D* and 5*E*.**	Group No. 1.	**Group No. 2 and 5*A*, 5*B* and 5*C*. 5*B* and 5*C* are dirtier than 5*A*.**		Group No. 4.	**All panels show decided chalking. Films are generally sound. Group No. 1, Some scaling over knots. Group No. 3, Some cracking.**
C. R. Cook Kansas City (Nos. 1, 2 and 4)	**Group No. 1. Dirt collection uniform for group.**	**Group No. 2. Dirt collection uniform for group.**			Group No. 4 *A*, Cleanest. *B*, Next. *C*, *D* and *E*, Dirtiest.	Group No. 1, Shows slight cracking. Group No. 2, Shows fine checking. Group No. 4, Shows excessive chalking.
R. E. Rogers Pittsburgh (Nos. 1, 2, 3 and 4)	Group No. 2. Dirt collection increases as *E*, *D*, *C*, *B* and *A*.	Group No. 1. Dirt collection increases as *E*, *D*, *C*, *B* and *A*.			Group No. 4. Dirt collection increases as *A*, *B*, *E*, *D* and *C*.	2*C*, 2*D* and 2*E*, Cleanest on fence.
F. G. Breyer Palmerton (Nos. 1, 2 and 4)	**Group No. 1. *E*, Cleanest. Others on a par, slightly more dirt than *E*.**	**Group No. 2. *E*, Cleanest. Dirt collection increases from *D* to *A*.**			Group No. 4. *A*, Cleanest. Dirt collection increases from *B* to *E*.	
R. L. Hallet Sayville (Nos. 1, 2, 3, 4 and 5)	**Group No. 3. All panels uniform.**	**All other groups uniform.**				**Panels exposed 4 months. All panels show loss of gloss.**
H. A. Gardner Washington (Nos. 1, 2, 3, 4 and 5)	Group No. 3 and 5*D* and 5*E*. 3*E* is possibly cleanest. 5*D* and 5*E*, good.	Group No. 1. All clean and sound.	Group No. 2. Some scaling.	Group No. 4. 4*D* and 4*E* possibly cleaner than others in group. Some scaling.	Group No. 5 (*A*, *B* and *C*). Very dirty in order given.	Scaling effects shown on some, probably due to lumber rather than to paint.

TABLE I.—RESULTS OF INSPECTION REPORTS BY INDIVIDUAL OBSERVERS (*Continued*): INSPECTION, JANUARY, 1926

Observer, Location and Groups Tested	**Cleanest**	Intermediate Ratings			**Dirtiest**	Remarks
P. R. Croll **Milwaukee** **(Nos. 1, 2, 3 and 4)**	Group No. 3. Dirt collection increases as *E*, *D*, *C*, *B* and *A*.	Group No. 1. All reductions uniform.	Group No. 2. All reductions uniform.		Group No. 4. Dirt collection increases as *A*, *B*, *E*, *C* and *D*.	Panel No. 1 shows slight cracking. Panel No. 2 shows marked failure and cracking of wood. Panel No. 3 free from checks and cracks. Panel No. 4 intermediate between No. 1 and No. 2.
W. D. Jones **San Francisco** **(Nos. 1, 2 and 4)**	Group No. 1. Dirt collection increases from *A* to *E*. 1*C*, Whitest panel.	Group No. 2. Dirt collection increases from *A* to *E*.			Group No. 4. Dirt collection increases from *A* to *E*.	Group No. 1 shows diminishing cracking from *A* to none in *E*. 2*A*, 2*B*, 4*A* and 4*B*, Considerable flaking
G. D. White Newark (Nos. 1, 2 and 4)	Group No. 1. *E*, Cleanest. Others uniform.	Group No. 2. *A* and *B*, Dirtiest. Others uniform.			Group No. 4. *A* and *B*, Cleanest. *C*, *D* and *E*, Dirtiest.	All groups badly cracked.
P. H. Walker Washington (Nos. 1, 2, 3, 4 and 5)	Group No. 3.	Group No. 5. 5*C* is dirtier than 5*A* and 5*B*.	Group No. 1.	Group No. 2.	Group No. 4. 4*E* and 4*D* are dirtier than 4*A*, *B* and *C*.	All panels show decided chalking.
C. R. Cook **Kansas City** **(Nos. 1, 2 and 4)**	Group No. 1. All uniform in dirt collection.	Group No. 2. All uniform in dirt collection.			Group No. 4. *E*, Dirtiest.	
R. E. Rogers Pittsburgh (Nos. 1, , 3 and 4)	Group No. 1. Dirt collection increases as *E*, *D*, *C*, *B* and *A*.	Group No. 2. *A*, *B*, *C*, *D* and *E* all on par.			Group No. 4. *A* and *B*, Cleanest. *C* and *D*, Next. *E*, Dirtiest.	Group No. 1 is practically free from dirt.
F. G. Breyer Palmerton (Nos. 1, 2 and 4)	Group No. 1. *E*, Cleanest. Others uniform.	Group No. 2. *E*, Cleanest and on a par with *A* to *D* of Group No. 1.			Group No. 4. Panels exhibit mottled appearance. Dirt collection increases from *A* to *E*.	
R. L. Hallett Sayville (Nos 1, 2, 3, 4 and 5)	Groups Nos. 1 and 3. All uniform in dirt collection.	Groups Nos. 2 and 4. All uniform in dirt collection.			Group No. 5. 5*C*, Dirtiest.	Panels exposed 7 months. All panels show chalking. Complete loss of gloss. Group 4 shows many wood cracks.
H. A. Gardner Washington (Nos. 1, 2, 3, 4 and 5)	Group No. 1 and 5*D* and 5*E*. 1*D* and 1*E*, Possibly best. 5*D* and 5*E*, Both white and sound.	Group No. 3. All clean and dense. 3*E*, Possibly cleanest. All show some scaling.	Group No. 5. 5*B* lighter than 5*A* or 5*C*. 5*C*, Quite dirty. All sound except for alligatoring of surface.	Group No. 4. All reductions uniform. All show some scaling due to wood.	Group No. 2. No difference in *A* to *D*. 2*E*, Possibly cleanest. All show scaling probably due to wood.	Repainting of tests to be started. Wood is now weathered and better results should be obtained.

REPORT OF SUB-COMMITTEE V ON LINSEED OIL

In taking up its work for the current year, Sub-Committee V found the following standard and tentative specifications bearing on linseed oil:

For Purity of Raw Linseed Oil from North American Seed (D 1 - 15);
For Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed (D 51 - 18 T);
For Purity of Raw Linseed Oil from South American Seed (D 77 - 21 T);
For Purity of Boiled Linseed Oil from North American Seed (D 11 - 15);
For Purity of Boiled Linseed Oil from South American Seed (D 78 - 21 T).

In addition to the above standard and tentative specifications, the sub-committee found that it had not yet complied with a request from Committee D-1, to prepare specifications for linseed oil covering both purity and quality.

At the sub-committee meeting held in June, 1925, it was decided that the geographical origin of the seed should not be used as a quality criterion for linseed oil but that suitable specifications should be drawn covering linseed oil regardless of geographical origin of the seed and that other specifications for oil should be drawn to correspond with the type of raw linseed oil with a high iodine value, this latter to take the place of the specifications now existing for linseed oil from North American seed.

The sub-committee also decided to make a further study in an attempt to obtain satisfactory methods for determining those components of linseed oil, commonly known as foots. It was deemed desirable to determine these ingredients in such a way as to differentiate between mucilaginous matter, solidifiable fats and moisture, all three of which may be constituents of the so-called foots. It was determined to try to develop new methods or to further refine or modify our present methods in such a way that duplicable results could be obtained in the average laboratory without the use of expensive apparatus or complicated procedure. In order to establish duplicability of results, cooperative work was to be done upon distributed samples. In order to determine proper limits, records were to be kept by large producers and consumers covering commercial shipments and receipts over a prolonged period.

The results obtained are given below. These results and a consideration of the general situation has led the sub-committee to conclude that the time is ripe to withdraw the existing standard and tentative specifications for raw linseed oil and to issue in their place, new tentative specifications, which are appended hereto.[1] In proposing these new tentative specifications, it is realized that they are not all that might be desired and it is not proposed to stop working on the subject. It is believed, however, that they will furnish the purchaser of linseed oil with a standard that will protect him against inferior material and, at the same time, that the producer with ordinary care will be able to furnish material meeting these specifications.

The specifications for boiled oil are now the subject of investigation and it is believed that some changes should be made in them but the sub-committee is not prepared at the present time to recommend any change. It hopes to be able to report next year on this point.

The sub-committee recommends the withdrawal of the following specifications:

Standard Specifications for Purity of Raw Linseed Oil from North American Seed (D 1 - 15);[2]

Tentative Specifications for Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed (D 51 - 18 T).[3]

Tentative Specifications for Purity of Raw Linseed Oil from South American Seed (D 77 - 21 T).[4]

The proposed Tentative Specifications for Raw Linseed Oil, appended hereto,[1] are offered in their stead.

EXPERIMENTAL DATA AND DISCUSSION

Foots:

In an effort to develop a satisfactory method for determining foots a great deal of work has been done individually by various members of the sub-committee. The sub-committee has also been in touch with other agencies working on the same or similar problems, among them being Mr. George S. Jamieson of the Oil, Fat and Wax Laboratory, Bureau of Chemistry, U. S. Department of Agriculture.

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[1] See p. 788.—ED.

[2] 1924 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 678 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 279.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 21, p. 613 (1921); also 1925 Book of A.S.T.M. Tentative Standards, p. 280.

Some of the work done by Jamieson and Baughman on the non-oil constituents of cotton seed oil may be of value in the future in building up a new method for use in linseed oil.[1] Work has been done by various members of the sub-committee on determination of "break," ash and various other possible criteria for mucilaginous matter in the oil. Work has also been done on the separation of solidifiable fats.

The development which seems to present the best solution of the problem, however, consisted in the refinements or modification of the present method. Mr. E. W. McMullen has suggested a modification in handling the solutions which eliminates transferring from one container to another, thereby doing away with one source of error. Mr. S. O. Sorensen of the Archer-Daniels-Midland Co., Minneapolis, Minn., has made a study of the effects of variations of the proportion of acid in the calcium chloride solution. His results indicate that minor variations have very little effect on the results. Mr. C. G. Wortz has studied the effect of varying temperatures of ingredients and times of agitation. As a result of his work, the procedure has been established in such a way as to eliminate any appreciable variations from these causes.

As a result of these preliminary investigations, three samples of linseed oil were distributed to various sub-committee members for cooperative work. Determinations were made on these three samples in accordance with the following directions:

1. Foots test according to method described in the A.S.T.M. Tentative Specifications for Foots Permissible in Properly Clarified Linseed Oil (D 51 - 18 T).

2. Heat a portion of the oil to 65° C., hold it at that temperature for 10 minutes, allow to cool to room temperature and subject it to the foots test by the above method.

3. *Ash Test.*—Ignite and weigh to an accuracy of 0.001 g., a porcelain crucible or small evaporating dish, having a capacity of about 50 cc. Into this container, weigh about 25 g. of linseed oil. Add 3 drops of concentrated sulfuric acid. Heat the oil over a gas burner carefully to the fire point, ignite the oil, remove the burner and allow the oil to burn quietly as long as possible. Proceed carefully in this way, avoiding foaming and renewing heat only when the oil ceases to burn. When all foaming has ceased, apply the full flame of the burner until all the carbon has been burned and the ash is uncontaminated by black particles. Cool the dish in a desiccator, weigh to an accuracy of 0.001 g., calculate the increase in weight as percentage of ash present in the oil.

The following observers reported on these samples:

1. F. S. Deacon, Congoleum-Nairn Inc., Kearny, N. J.
2. F. E. Walker, Congoleum-Nairn Inc., Camden, N. J.

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[1] See *Journal of Oil and Fat Industries*, Volume 2, No. 3, July, 1925.

3. C. M. Ritterson, Congoleum-Nairn Inc., Salem, N. J.
4. C. G. Wortz, Congoleum-Nairn Inc., Marcus Hook, Pa.
5. R. B. Rohrer, Armstrong Cork Co., Lancaster, Pa.
6. C. S. Hollinger, John Lucas and Co., Inc., Gibbsboro, N. J.
7. J. B. Davis, Standard Textile Products Co., 320 Broadway, New York City.
8. S. O. Sorensen, Archer-Daniels-Midland Co., Minneapolis, Minn.
9. E. W. McMullen, Simmons Company, Kenosha, Wis.
10. F. A. Hull, General Electric Co., Schenectady, N. Y.

The following table shows the results obtained on these cooperative tests:

TABLE I.—"FOOTS" AND ASH DETERMINATIONS MADE ON THREE SAMPLES OF LINSEED OIL.

Observer	Foots Test, Oil Heated to 65° C.			Foots Test, Oil at Room Temperature			Ash Determinations		
	Sample No. 60	Sample No. 61	Sample No. 62	Sample No. 60	Sample No. 61	Sample No. 62	Sample No. 60	Sample No. 61	Sample No. 62
No. 1	0.4	0.8	2.8	0.6	1.8	5.2	0.093	0.085	0.160
No. 2	0.2	0.8	3.2	0.8	2.0	4.0	.....	0.100	0.140
No. 3	0.8	1.0	3.2	1.0	1.2	4.8	0.083	0.095	0.158
No. 4	0.33	0.93	4.0	0.8	1.4	5.2	0.089	0.107	0.129
No. 5	0.4	0.6	3.2	1.2	1.4	6.4	0.093	0.094	0.135
No. 6	0.0	0.8	2.4	1.2	2.0	6.4	0.119	(0.144)	0.131
No. 7	0.3	1.0	3.6	0.4	1.2	3.6	0.082	0.068	0.086
No. 8	0.4	0.4	(9.2)	1.6	1.8	9.2	0.110	0.114	0.149
No. 9	1.2	1.2	4.3	1.6	2.4	5.6	0.091	0.102	0.109
No. 10	0.0	(0.0)	(0.0)	1.6	1.6	6.0	0.120	0.100	0.120
Average	0.40	0.83	3.34	1.1	1.7	5.6	0.097	0.096	0.132
Maximum	1.2	1.2	4.3	1.6	2.4	9.2	0.120	0.114	0.160
Minimum	0.0	0.4	2.4	0.4	1.2	3.6	0.082	0.068	0.086
Deviation above mean, per cent	200	41	29	45	41	64	24	19	21
Deviation below mean, per cent	100	52	28	64	29	36	15	29	35

The results obtained on heated samples indicated better concordance than previous work on the foots test and gave promise that with the refinements noted above, we might develop a satisfactory test for mucilaginous matter.

In addition to the results reported several large producers and consumers of linseed oil kept a record of their results on current shipments and receipts of commercial raw linseed oil. The results which are shown in Table II represent examination of nearly 200 separate lots of oil ranging in volume from tank car to tank boat volumes.

The tests recorded in Table II indicate that the foots as determined on the heated sample average only 0.48 per cent on commercial deliveries of oil. In only 6 instances out of nearly 200 tests did the material show over 1.0 per cent foots when the test was made upon the heated oil. Results on oil which had been chilled at 0° C. showed an average of about 2 per cent foots. A number of confirmatory tests by individual operators also indicated that foots in a satisfactory grade of raw linseed oil which had been heated and then chilled for 2 hours at 0° C. averaged about 2 per cent and never exceeded 4 per cent.

The ash determination which it had been hoped would furnish us with a satisfactory criterion for mucilaginous matter did not give concordant results. See Tables I and II.

Table II.—Ash and Foots Tests, Factory Records of Receipts or Shipments.

	Observer									Average	Maximum	Minimum	Deviation Above Average, per cent	Deviation Below Average, per cent
	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8	No. 9					
	Jan., 1926	Feb., 1926	Jan., 1926	Feb., 1926	1924–1925	Jan. to Mar., 1926	Jan., 1926	Jan., 1926	Feb., 1926					
Foots, Regular Method:														
Average	0.82	0.60	1.80	1.73	.....	1.20	2.50	.....	.....	1.44	2.50	0.60	74.0	58.0
Maximum	1.60	1.00	3.20	2.80	.....	1.60	2.80	.....	.....	2.16	3.20	.....	122	......
Minimum	0.20	0.40	1.20	0.80	.....	0.80	2.40	.....	.....	0.96	.....	0.20	......	86
Foots, Heated:														
Average	0.56	0.47	0.46	0.49	0.40	0.63	0.50	0.40	0.45	0.48	0.63	0.40	26.0	20.0
Maximum	1.20	0.80	1.00	0.80	2.00	0.90	1.20	0.4	0.6	1.13	2.00	.....	300	......
Minimum	0.20	0.20	trace	trace	trace	0.40	trace	0.4	0.4	0.11	.....	trace	......	100
Foots, Chilled:														
Average	2.10	1.85	.....	.....	.....	.....	.....	.....	.....	1.97	2.10	1.85	6.6	6.1
Maximum	3.60	3.60	.....	.....	.....	.....	.....	.....	.....	3.60	3.60	.....	83	......
Minimum	0.60	0.60	.....	.....	.....	.....	.....	.....	.....	0.60	.....	0.60	......	0.70
Foots, Centrifuged:														
Average	.....	.....	1.01	1.72	.....	.....	.....	.....	.....	1.36	1.72	1.01	26.5	26.0
Maximum	.....	.....	4.00	3.30	.....	.....	.....	.....	.....	3.65	4.00	.....	194	......
Minimum	.....	.....	0.20	0.20	.....	.....	.....	.....	.....	0.20	.....	0.20	......	85
Foots, 80 per cent $CaCl_2$:														
Average	0.84	0.68	.....	.....	.....	.....	.....	.....	.....	0.76	0.84	0.68	10.5	10.5
Maximum	1.60	1.30	.....	.....	.....	.....	.....	.....	.....	1.45	1.60	.....	110	......
Minimum	0.20	0.40	.....	.....	.....	.....	.....	.....	.....	0.30	.....	0.20	......	73
Ash:														
Average	0.169	0.153	0.105	0.084	.....	0.070	0.078	0.110	0.056	0.103	0.169	0.056	64.0	45.7
Maximum	0.297	0.179	0.170	0.160	.....	0.112	0.090	0.111	0.072	0.168	0.297	.....	188	......
Minimum	0.105	0.127	0.062	0.061	.....	0.041	0.070	0.110	0.040	0.077	.....	0.041	......	60
Number of Samples	38	17	27	24	.58	9	3	2	3	..	..	..	..	..

After considering the evidence herein presented and a great deal of additional data which is too voluminous to record, the sub-committee is of the opinion that at the present time, our most satisfactory criterion for foots is the determination on oil which has been heated to 65° C. to give a measure of the mucilaginous matter in the oil, and secondly, a determination on oil which has been chilled to 0° C. which gives a measure of the mucilaginous material plus fats which are easily solidifiable in the cold and which tend to separate from the oil during the cold weather. The sub-committee believes that 1 per cent and 4 per cent, respectively are proper maximum limits for foots as determined under these two conditions.

Specific Gravity:

The committee has been in receipt of several communications from various sources protesting that our minimum allowable specific gravity 15.5°/15.5° C. of 0.932 was too high.

After reviewing the available evidence and also considering the work done by the sub-committee in previous years, the specific gravity range has been set at 0.931 to 0.935.

Acid Number:

The previous maximum allowable acid number of 6.0 is believed by the sub-committee to be too high. Great variation in acid number is the cause of serious difficulty in paint and varnish making. After considering a mass of evidence covering acid number determinations of commercial linseed oil, the sub-committee proposes a maximum acid number of 4.0. It is also proposed to use benzol-alcohol mixture in place of the alcohol in the determination. This conforms with practice in testing of tung oil and gives, in the opinion of the committee, more concordant results.

Unsaponifiable Matter:

The sub-committee proposes for the unsaponifiable matter determination, the method used in the Standard Specifications for Perilla Oil Raw or Refined (D 125 – 23). It is believed that this method is simpler and more satisfactory than the Boemer method previously specified.

Refractive Index:

Since this method seems to have comparatively little value in distinguishing linseed oil from most other vegetable oils, it is recommended that it be omitted.

Iodine Number:

During previous years, Sub-Committee V has done a large amount of work in comparing results by the Hanus method and the Wijs method of making iodine number determinations. In view of the fact that the Wijs solution is generally used in testing shellac, tung oil and various other materials, it is felt that its use should be specified in preference to the Hanus solution which cannot be so generally utilized. Previous extensive work of this sub-committee has indicated that results by the Wijs method averaged from 4 to 5 points higher than by the Hanus method and the standard will therefore have to be adjusted accordingly.

In considering the minimum limit for iodine number, the records of past investigations by this sub-committee have been taken into account, and also the factory records, covering a number of years furnished by various members of the sub-committee. On the basis of these records, a minimum iodine number of 180 for linseed oil is proposed. This would correspond to about 175-176 by the Hanus method. For the high-iodine-number type of linseed oil, a minimum iodine number of 188 is proposed. This would correspond to about 183-184 by the Hanus method.

Loss on Heating:

This determination helps to detect excessive moisture or contamination with a volatile solvent. The method is that used in U. S. Government Specifications, Bureau of Standards *Circular No. 82.*

Color:

In order to eliminate any excessively dark oil which would not be ruled out under any other provision of the specifications, an item of color, has been inserted, which is also taken from U. S. Government Specifications, Bureau of Standards *Circular No. 82.*

Respectfully submitted on behalf of the sub-committee,

R. D. BONNEY,
Chairman.

REPORT OF SUB-COMMITTEE VII ON ACCELERATED TESTS FOR PROTECTIVE COATINGS

Sub-Committee VII on Accelerated Tests for Protective Coatings held its organization meeting June 25, 1925. One meeting has been held since then on March 17, 1926.

The plans of the sub-committee provide for cooperative test work on panels to compare accelerated weathering schemes now in use with outdoor exposure results. This part of the program has been delayed to give members opportunity to install apparatus and gain some experience in its operation. Ten members are now more or less completely equipped for this work and it is planned to have the panels ready for cooperative tests in June.

The sub-committee considers that a very important part of its work is to gather information about accelerated tests for protective coatings that have been tried in the past and study their possibilities. Reports of this nature have been solicited. Mr. E. D. Gregory has kindly cooperated by furnishing a report covering the seeming correlation between outdoor exposures on metal priming paints and the results of an accelerated corrosion test (sulfur dioxide, oxygen and steam) that was used by N. A. DuBois in 1913.

A brief preliminary report of work done in trying to verify the results reported by Mr. Gregory by other accelerated tests, has also been submitted by Messrs. Nelson and Schmutz. Mr. F. W. Hopkins has submitted a description of his accelerated weathering apparatus with which he reports satisfactory preliminary results. These reports are in the hands of the sub-committee members for study and discussion. Other reports have been definitely promised that will furnish ample material for future work.

Respectfully submitted on behalf of the sub-committee,

F. G. Breyer,
Chairman.

REPORT OF SUB-COMMITTEE VIII ON METHODS OF ANALYSIS OF PAINT MATERIALS

The sub-committee recommends that the Tentative Method of Test for Coarse Particles in Paint Pigments (D 185 - 24 T)[1] be revised as follows and that the method as revised be adopted as standard:

Section 1.—For the word "standard" in the first line substitute "3-in.," and change the second sentence to read as follows:

> "A 3-in. No. 325 sieve for comparison purposes should be retained in the laboratory as a standard."

Section 5.—Change the last sentence of the first paragraph from its present form: namely,

> "This operation shall be continued until typewritten letters can be read through a layer of the wash liquid 8 cm. thick, which is approximately the height of a filled 250-cc. beaker of the low form (Griffin) type."

to read as follows:

> "This operation shall be continued until the wash liquid passing over the residue and through the sieve is clear and free from solid particles."

Insert a note to read as follows:

> "NOTE.—When the operator thinks he has completed the washing he should catch about 200 cc. of the liquid in a clean 400-cc. beaker, stir vigorously and set the beaker on a black surface in the case of white pigments and a white surface in the case of colored pigments. The washing is not complete until a test as described above fails to show any particles collected about the middle of the bottom of the beaker."

It is recommended that the modification of the Parks and Van Heuckeroth method of test for specific gravity of pigments be accepted for publication as tentative as appended hereto.[2] This method, a modification of Thompson's method,[3] was originally published in *Circular No. 242*, Educational Bureau, Paint Manufacturers' Association of the United States, July, 1925.

It is recommended that the Tentative Methods of Routine Analysis of White Linseed-Oil Paints (D 215 - 25 T), as published in the Proceedings, be continued as tentative during the coming year.

Respectfully submitted on behalf of the sub-committee,

F. W. SMITHER,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 857 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 302.

[2] See p. 811.—ED.

[3] *Proceedings*, Am. Soc Testing Mats., Vol. XIII, p. 407 (1913).

REPORT OF SUB-COMMITTEE IX ON VARNISH

During the past year the committee has continued the work previously outlined.

GROUP 1.—THE EFFECT OF TEMPERATURE AND HUMIDITY ON DRYING

J. McE. Sanderson, chairman, reports interesting data on the effect of temperature and humidity on drying. The group secured cooperation from the following: Prof. G. H. Resides, The Pennsylvania State College; Mr. G. M. Hunt, U. S. Forest Products Laboratory; V. V. Woodward, Commander, U. S. Navy Yard; Dr. F. P. Veitch, U. S. Department of Agriculture.

Considerable time was spent in the further development of the drying-time meter described by the chairman at the annual meeting June, 1925;[1] also in the investigation of equipment necessary for proper regulation of temperature and humidity.

It was found that few laboratories were equipped with the rather elaborate and expensive equipment necessary for complete and accurate regulation of temperature and humidity, but that among those who were cooperating in this work there was sufficient equipment to carry on a limited number of tests.

Owing to the time expended in the preliminary investigation, actual work was not started until so late that the time available before the presentation of this report was very short. Samples of two different varnishes were sent to each laboratory with the request that drying tests be made at the following points:

45° F.	30 – 60 – 90 per cent humidity
70° F.	30 – 60 – 65 – 90 per cent humidity
80° F.	30 – 60 – 90 per cent humidity
95° F.	30 – 60 – 90 per cent humidity

The following directions were transmitted to the cooperators:

> Tests are to be made by pouring the varnish on glass and allowing to drain in a vertical position so as to get a flow of approximately 6 in. in length. Before starting the test, the glass plate, as well as the material, should be brought to the temperature at which the test is to be conducted. After the varnish is flowed on, touch lightly with the finger at a point 2 in. from the top at 10-min. intervals until it is perceptibly changed from a wet to a sticky condition. Consider this the point of "initial set." Continue touching lightly at 20-min. intervals until the finger can be drawn lightly over the surface without feeling sticky. At this point, the varnish

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part II, p. 407 (1925).

would be considered "dust-free." Continue touching at intervals of one-half hour until a firm pressure of the finger tip does not make a distinct impression. At this point, the varnish would be considered "dried hard."

Supplementary directions were also sent out as follows:

> It has been suggested that the time of initial set can best be determined by flowing the varnishes on glass according to previous directions and drawing the point of a pin rapidly across the film at a point about 2 in. below the top. Do this at 10-min. intervals and report as initial set the time when the mark does not flow together but remains permanently.

It was also requested that those who were equipped with the drying-time meter run check tests.

Reports received from five operators are given in the following table:

Temperature, deg. Fahr.	Humidity, per cent	Varnish No. 612						Varnish No. 602					
		Set		Dust-Free		Hard		Set		Dust-Free		Hard	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
40	30	75 min.	..	48 hr.	..	..	..	75 min.	..	30 hr.	..	..	..
70	30	20 "	60 min.	7 "	13 hr.	21 hr.	23 hr.	30 "	60 min.	$5\frac{1}{2}$ "	7 hr.	12 hr.	23 hr.
70	60–65	30 "	60 "	6 "	13 "	$11\frac{1}{2}$ "	$30\frac{1}{2}$ "	30 "	60 "	$5\frac{1}{2}$ "	$9\frac{1}{2}$ "	11 "	23 "
70	90	40 "	..	6 "	..	$11\frac{1}{2}$ "	..	40 "	..	5 "	..	$12\frac{1}{2}$ "	..
80	30	20 "	30 "	$5\frac{1}{4}$ "	12 "	12 "	22 "	20 "	30 "	$4\frac{2}{3}$ "	$5\frac{2}{3}$ "	$11\frac{1}{4}$ "	22 "
80	60	30 "	30 "	$5\frac{1}{3}$ "	8 "	$9\frac{1}{4}$ "	24 "	30 "	30 "	$4\frac{3}{4}$ "	6 "	$8\frac{1}{4}$ "	14 "
80	90	30 "	..	$3\frac{1}{2}$ "	..	7 "	..	30 "	..	$3\frac{1}{2}$ "	..	$7\frac{1}{2}$ "	..
95	30	20 "	25 "	5 "	$6\frac{1}{2}$ "	21 "	23 "	10 "	25 "	$4\frac{1}{2}$ "	$5\frac{1}{2}$ "	12 "	23 "
95	90	25 "	..	6 "	..	19 "	..	25 "	..	5 "	..	11 "	..

Analysis of the above results confirms the observation, previously made by Sub-Committee IX,[1] that drying tests under the same conditions on the same materials by different operators do not agree closely and that the varying stages in the drying period are not exactly defined.

The drying of a paint or varnish film consists in a gradual change from a liquid to a solid state. During this change there are three points, or rather transition periods, the determination of which will determine the drying of the material at least for practical usefulness.

The first of these periods is the time of initial set when the material ceases to flow, so that in brush application working beyond this time would show brush marks or in spray application the material would not flow out to a smooth film. The method of scratching with a pin and observing the time when this mark no longer flows out yielded slightly more definite results than touching with the finger as originally suggested. An attempt will be made to adapt this pin scratch for mechanical recording on the drying-time meter.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 381 (1922).

The second period in drying is that usually termed "drying dust free," that is, when the material is sufficiently dry on the surface so that dust does not adhere readily and when it may be handled gently without marring. Tests indicate that this period may be accurately determined and recorded by the drying-time meter.

The third period is the time of drying-hard when the film has so nearly reached the solid state that it requires considerable pressure to mark it. So far no definite method for the determination and recording of this point has been worked out. Several methods have been proposed for the determination of the degree of final hardness, and an effort will be made to adapt one of these methods to the drying test.

The outstanding feature of this work so far is the indication of the necessity for mechanical means of testing and recording to eliminate the personal equation of different operators in drying tests. Another point is the desirability of getting more laboratories equipped for close control of all factors affecting drying to permit a study of the exact effects of variations in each of these conditions.

GROUP 2.—LINSEED OIL ADDITION TEST

E. A. Stoppel, chairman, reports results in the use of the Linseed Oil Addition Test which justify the sub-committee in recommending that the test be adopted as tentative as appended hereto.[1]

The work undertaken by this group was to determine the elasticity or toughness of varnishes which are less elastic than zero reduction on the Kauri Reduction Test. This was done by what has been designated as the "Linseed Addition Test for Elasticity." This test is the same as the present standard Kauri Reduction with the exception that the 33⅓ per cent solution of run Kauri gum in turpentine is replaced by a 66⅔ per cent solution of bodied linseed oil in turpentine. The test was to be carried out according to the following instructions:

THE LINSEED ADDITION TEST FOR ELASTICITY

Preparation of Bodied Oil.—A high grade of alkali refined linseed oil, the acid number of which should be less than 1.0, is used for making the bodied oil required in this test. This oil is bodied in an open kettle at 560° F. (a leeway of 10° in either direction being allowed) until its body as measured in poises shall lie between 7.00 and 7.50 poises or when made up into Standard Linseed Solution shall lie between 0.65 and 0.75 poises.

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[1] See p. 814.—ED.

Preparation of Standard Linseed Solution.—Two parts by weight of the bodied oil are carefully mixed with one part by weight of re-distilled turpentine to make the addition solution correspond to the Reducing Solution of the Kauri Reduction Test.

Detail of Test.—The addition to the varnish, flowing procedure and details of the elasticity test itself which follow are the same as for the Kauri Reduction Test, except that the Oil Addition Solution takes the place of the Kauri Reduction Solution.

Addition to the Varnish.—Having already established the fact that the material being tested breaks at zero reduction under the conditions of the Kauri Reduction Test, and having carefully determined the non-volatile content according to the method of Determination of Non-Volatile Matter described below, take 100 g. of the varnish and add to it an amount of Standard Linseed Solution equivalent to 50 per cent by weight of the non-volatile matter in the varnish. Mix the varnish and the solution thoroughly. For the sake of simplicity the amount of varnish to be used is given as 100 g., whereas 25 g. is sufficient, and taking the smaller amount will conserve the supply both of the sample and of the Standard Linseed Solution.

Flow.—Place a coat of the varnish thus reduced on a standard 3 by 5-in. tinned panel, carefully cleaned with benzol, and allow it to dry in a nearly vertical position at room temperature for one hour. Next place the panel in a horizontal position in a properly ventilated oven and bake it for five hours at from 96 to 100° C. (205 to 212° F.). Remove the panel and allow it to cool at room temperature, preferably 75° F., for one hour.

Bending the Panel.—Place the panel with the varnish side uppermost over a 3-mm. ($\frac{1}{8}$ in.) rod, held firmly by suitable supports at a point equi-distant from the top and the bottom edges of the panel, and bend the panel double rapidly. If sufficient Addition Solution has been used the varnish should show no cracking at the point of bending. For accurate results the bending of the panel should always be done at 75° F., for lowering the temperature will increase the percentage of addition that the varnish will require before passing the bending test, while raising the temperature will decrease the addition.

If the varnish, when tested as outlined in the preceding paragraph, does not crack with the 50 per cent addition specified, make up additional samples using lesser amounts of Standard Linseed Solution until a point is reached where it just cracks and no more. If, on the other hand, the varnish does crack with the addition of 50 per cent, prepare other samples with larger amounts of the Standard Linseed Solution added, until the cracking-point on subsequent baking and bending is determined.

The panels required for this test are of bright tin 3 by 5 in. and approximately 0.278 to 0.297 mm. (0.0109 to 0.0117 in.) thick. The weight of the metal per standard base box, 112 sheets 14 by 20 in., Nos. 31 and 30½, United States standard plate gage, is 90 to 100 lb. They should be thoroughly cleaned with benzol immediately before using.

Determination of Non-Volatile Matter.—A prerequisite to running a linseed addition test is a non-volatile determination. It has been found that it is sometimes difficult to obtain the correct non-volatile percentage on resin solutions or short oil varnishes by the usual methods. The non-volatile matter is so hard that it prevents the transfusion and escape of all of the thinners. This is overcome, however, by the addition of a fixed oil, such as castor. Since the series of varnishes tested included some very short oil varnishes, members were requested to determine the non-volatile matter by the A.S.T.M. method on the varnish as received and after the addition of 10 per cent of castor oil.

The Linseed Addition Test involves the use of a bodied linseed oil. The test as outlined requires the viscosity of this oil to lie between 7.00 and 7.50 poises. It is very difficult to body linseed oil and stop the heating at just the right time to obtain an oil lying within these narrow limits. It would be very desirable to widen this range if possible. With this in view, the group did some work to determine how results are affected if an oil of a much higher or lower viscosity is used.

In addition to running the Linseed Addition Test, members were asked to run such other tests as time permitted, including:

1. Color
2. Viscosity
3. Drying Time
4. Water Test

For carrying on the work, each member was supplied with two half pint cans of varnishes designated as varnish B-1, B-2, B-3, B-4, B-5 and B-6, also two cans of bodied linseed oil with a viscosity of 7.25 poises and one each of oil of 5 and 21 poises. The results of the tests are tabulated:

Operator		Varnish Designation					
		B-1	B-2	B-3	B-4	B-5	B-6
NON-VOLATILE MATTER, PER CENT							
Breyer	without castor oil	41.08	52.66	47.56	49.71	48.60	48.47
	with castor oil	41.01	52.51	47.39	49.65	48.60	48.32
Gardner	without castor oil	41.28	52.93	47.98	49.80	49.29	48.80
	with castor oil	....	....	....	....	....	....
Graves	without castor oil	40.7	....	48.8	....	48.3	....
	with castor oil	40.5	....	46.2	....	48.5	....
Pearce	without castor oil	40.52	51.16	46.91	49.50	48.32	48.20
	with castor oil	41.33	52.83	46.55	48.95	48.76	48.37
Stoppel	without castor oil	40.50	52.40	48.45	49.35	48.70	48.90
	with castor oil	40.48	52.95	46.35	49.22	48.85	48.78
Average	without castor oil	40.82	52.29	47.94	49.59	48.64	48.79
	with castor oil	40.83	52.76	46.61	49.27	48.68	48.57
LINSEED OIL ADDITION TEST							
Gardner		20 to 30	40 to 50	70 to 80	0	10 to 20	30 to 40
Graves		65 to 70	..	105 to 110	..	40 to 45	55 to 60
Pearce		40	90	90	0	40	60
Stoppel		50 to 60	90 to 100	100 to 110	10 to 20	40 to 50	60 to 70
COMPARISON OF VARIOUS BODIED OILS FOR ADDITION, PER CENT							
Pearce	Viscosity 5.00	..	100	..	..	45	70
	Viscosity 7.25	40	90	90	0	40	60
	Viscosity 21.00	40	90	85	..	..	..
Stoppel	Viscosity 5.00	50 to 60	90 to 100	100 to 110	10 to 20	40 to 50	60 to 70
	Viscosity 7.25	50 to 60	90 to 100	100 to 110	10 to 20	40 to 50	60 to 70
	Viscosity 21.00	50 to 60	90 to 100	100 to 110	10 to 20	40 to 50	60 to 70

Operator		Varnish Designation					
		B-1	B-2	B-3	B-4	B-5	B-6
COLOR							
Gardner (Gardner-Holt Method)		6	7	8	5	5	6
Graves (A.S.T.M. Method)		1	..	2	..	1–	1
Pearce (A.S.T.M. Method)		1.0	1.0	1.7	0.7	0.6	0.7
Stoppel (A.S.T.M. Method)		2	1	2	2	2	2
VISCOSITY, POISES							
Gardner		1.65	3.70	5.00	5.00	0.65	1.00
Graves		1.65	....	5.50	....	0.85	1.00
Pearce		1.40	3.20	4.70	4.00	0.65	0.90
Stoppel		1.75	3.65	4.70	4.00	0.60	1.00
DRYING TIME, HOURS							
Graves (Temperature 78° F.)	Touch	6	..	3.5	..	4.5	4.5
	Hard	..	..	..	..	..	..
Pearce (Temperature 75° F., Humidity 34 to 70 per cent)	Touch	2.5	2.5	2	1.75	2.5	2.5
	Hard	15	14	7	13.5	8	6
Stoppel (Temperature 74° F., Humidity 21 percent)	Touch	6	5	2	3.25	5	3.75
	Hard	8 to 18	8 to 18	6	6.5	7	6
WATER TEST							
Gardner		White in 24 hr.	Considerably white	Whitened	Slightly white	O. K.	Slightly white
Graves		Clears in 20 min.	....	Clears in 2 hr.	....	White in 24 hr.	Clears in 20 min.
Pearce		White soft in 2 hr.	Slightly white in 2 hr.	Clears in 1.5 hr.	Clears in 1 hr.	Clears in 1.5 hr.	Slightly white in 2 hr.
Stoppel		White in 24 hr.	White in 24 hr.	Unaffected	Clears in 20 min.	Unaffected	Clears in 20 min.

COMMENTS BY VARIOUS OPERATORS

W. H. Graves.—The non-volatile matter of the varnishes was checked in the regular manner and with the addition of 10 per cent castor oil. The results check on the varnishes which have a comparatively long drying time but do not check on the varnishes with the shorter drying times. This seems quite logical and it is believed that the addition of castor oil gives more reliable results, but this can best be checked by comparing with known varnishes.

The elasticity of the varnishes was easily checked and providing these results check with other laboratories this is an excellent test.

W. T. Pearce.—In answer to your question concerning the viscosity of the oil used in the reductions, I would give as my opinion that limits between 7.00 and 9.00 would be quite satisfactory. As you will see from our results, we note very little difference between a very light oil and a very heavy oil. In regard to the determination of non-volatile, I had no difficulty in securing good checks.

E. A. Stoppel.—In regard to the non-volatile determination on the six varnishes, I found that practically the same percentage of non-volatile was found on the varnish when determined by the usual A.S.T.M. Method, and

TABLE I.—RESULTS OF VARNISH TESTS AT FOUR EXPOSURE STATIONS.

Panel No.	Booge and Gregory, Wilmington			Gardner and Parks, Washington			Johnston, Buffalo	Richardson, Detroit
	August 1, 1925	September 1, 1925	October 1, 1925	August 1, 1925	September 1, 1925	October 1, 1925	October 1, 1925	October 1, 1925
3M1	Beginning of very fine checking.	Panel 50 per cent covered with checking.	Quite finely checked all over. Good adhesion.	Start of minute scaling visible with glass. Good gloss.	Very minute checking visible to eye all over panel.	Very pronounced checking in several large areas. Loss of gloss.	Very slight checking. Rather poor appearance. Poor gloss.	Deep longitudinal crazing, fine checking. Some peeling. Lustre gone.
3M2	Beginning of very fine checking.	Panel 60–70 per cent covered with checking.	Finer checks than 3M1. Checked all over. Adhesion very good.	Same as 3M1, but more pronounced. Good gloss.	Same as 3M1, but more pronounced.	Very pronounced checking in several large areas. Some cracking. Loss of gloss.	Very slight checking. Rather poor appearance. Poor gloss.	Fine checking seen through glass. Some longitudinal crazing. Lustre gone.
3M3	Panel 20 per cent covered with checking.	Panel 60–70 per cent covered with checking.	Checked all over. Between 3M1 and 3M2 in fineness. Good adhesion.	Minute checking over entire surface. More pronounced than above.	Checking is finer than above and covers entire surface as a lacework.	Very pronounced checking in several large areas. Loss of gloss.	Poor general appearance. Bad checking. Rather poor gloss.	Dense fine checking, fairly deep. Lustre gone.
2S1	Beginning of very fine checking.	Panel 70 per cent covered with checking.	Very finely checked and rusted all over. Some checks have opened into slight peeling.	Very minute checking over entire surface.	3 or 4 rust streaks formed. Several pinhole ruptures forming.	Corrosion apparent at number of larger pinholes. 3 or 4 rust streaks. Loss of gloss. Very minute checking.	Rather poor appearance. Slight checking. Rather poor gloss.	Criss cross long hair line crazes, with fine checking. 10–15 per cent. Rusting and lifting.
2S2	Beginning of very fine checking.	Panel 80 per cent covered with checking.	Badly checked and rusted. Blistered. Slight peeling.	O. K.	Checking not so pronounced as above.	Very pronounced checking. Corrosion at number of larger pinholes. Whitened.	Slight checking. Rather poor appearance. Rather poor gloss.	Longitudinal crazes, fine checks. 15–20 per cent. Rusting and lifting.
2S3	Panel 20 per cent covered with checking.	Panel 90 per cent covered with checking.	Badly checked and rusted. Worst peeling of steel panels.	Very minute checking slightly more pronounced than 2S1.	Entire surface covered with fine lacework of checking visible to the eye.	Very pronounced checking. Few small corrosion spots.	Poor appearance. Very bad checking. Rather poor gloss	Fine dense checking visible through glass. Fair gloss remains. 25–30 per cent rusting.
SJ1	Panel 20–30 per cent covered with checking.	Completely failed.	Finely checked all over. Adhesion quite good. Slight peeling and rusting.	Considerable small scales forming all over surface.	Much scaling shows black surface beneath.	Film beginning to go as checking proceeds. Scale spots showing black beneath.	Fair appearance. Very slight checking. Fair gloss.	Fine checks over surface of panel with varnish completely gone in small areas.
SJ2	Panel 30 per cent covered with checking.	Completely failed.	Quite fine checking. Slight peeling. No rusting.	Pronounced pinhead scales.	Some peeling and long white streaks.	Varnish completely gone.	No checking. Rather poor appearance. Fair gloss.	Appreciable area bare of varnish. Long deep cracks criss crossing.
SJ3	Panel 90 per cent covered with checking.	Completely failed.	Very fine microscopic checking. Slight peeling. No rusting.	Some pinheads developed. Some scaling.	Some whitening due to scaling. Some peeled spots.	Some whitening due to scaling. Some peeled spots from which the varnish is gone.	Medium checking. fair gloss. Rather poor appearance.	Lifting from undercoats causes whitening. Long hair line crazes. Dense fine checking.

TABLE I.—RESULTS OF VARNISH TESTS AT FOUR EXPOSURE STATIONS (*Continued*).

Panel No.	Booge and Gregory, Wilmington			Gardner and Parks, Washington			Johnston, Buffalo	Richardson, Detroit
	August 1, 1925	September 1, 1925	October 1, 1925	August 1, 1925	September 1, 1925	October 1, 1925	October 1, 1925	October 1, 1925
BJ1	Beginning of very fine checking.	Panel 50–70 per cent covered with checking.	Very fine microscopic checking. One-half the panel peeled off.	Badly spotted with white scales where varnish has failed.	Badly streaked with white scale. Entire panel whitened.	Varnish completely gone.	Fair appearance. No checking. Fair gloss.	Lifting of film. Longitudinal cracks. Star checks seen through glass.
BJ2	Panel 10 per cent covered with checking.	Panel 80 per cent to completely covered with checking.	90 per cent peeled off.	Same as BJ1.	Varnish peeled off in spots shows black beneath. Very gray due to scaling.	Varnish peeled off in spots showing black under number of scale spots.	Poor appearance. Very slight checking. Fair gloss.	Varnish completely gone on both panels.
BJ3	Panel 10-20 per cent covered with checking.	Completely covered with checking. Failed.	Quite fine checking, not as fine as BJ1. Better adhesion.	Few small scales forming at bottom and minute ones over surface.	Few minute scales. Few peeling spots show black beneath. Very gray due to scaling.	Very gray appearance due to scaling. Few peeling spots showing black beneath.	Poor appearance. Bad checking. Fair gloss	Varnish gone from one-eighth of surface. Remainder shows varnish in last stages of lifting.
DJ1	Beginning of very fine checking.	Panel 50–70 per cent covered with checking.	Very finely checked. Slight scaling at top. No rusting.	Slight scaling around pinheads.	Indications of long cracks starting.	Varnish completely gone.	Fair appearance. No checking. Fair gloss.	Long hair line crazing. Star checks seen with glass.
DJ2	Beginning of very fine checking.	Panel 70–80 per cent covered with checking.	Same as DJ1. Slightly more peeling.	Indications of start of fine checking. Also start of scaling.	Entire surface covered with fine checking. Some scaling. A few long cracks.	Varnish completely gone.	Rather poor appearance. Very slight checking. Fair gloss	Long hair line crazing. Fine dense checks seen through glass.
DJ3	Panel 10–30 per cent covered with checking.	Panel 90 per cent covered with checking.	Very fine checking. Less peeling than DJ1 and DJ2.	Evidence of minute pinheads just forming.	Entire surface covered with checking. Otherwise sound. Best panel.	Some scale spots and pinheads. Otherwise sound.	Rather poor appearance. Medium checking. Fair gloss.	
G1	O. K.	Beginning of very fine checking.	Very finely checked. Started to peel badly. Large areas peeled off.	O. K.	Apparently O. K. Loss of gloss.	Varnish completely gone.	Rather poor appearance. No checking. Rather poor gloss.	No checking nor crazing. Some pitting. Fair lustre.
G2	O. K.	Beginning of very fine checking.	Peeled completely off.	O. K.	Apparently O. K. Loss of gloss.	Varnish completely gone.	Rather poor appearance. No checking. Rather poor gloss.	Peeled completely off.
G3	O. K.	Panel 10 per cent covered with checking.	Very finely checked. Some areas peeled off.	O. K.	Apparently worst of G panels. Loss of gloss.	Some small spots still covered with varnish.	Bad checking. Rather poor gloss.	Fine dense checking. Some of lustre remains.

after the addition of 10 per cent castor oil. Only in one varnish, B-3, was there a variation of more than one per cent, and this was an extremely high resin varnish, as subsequently shown on the oil addition test. I believe that the addition of castor oil is not necessary in determining the non-volatile matter in varnish, even in short oil varnishes, at least covering the range on which these tests were made.

Regarding the linseed oil addition test, I believe that this is a valuable means for determining the relative elasticity of a varnish not covered by the present Kauri test. The test was made using not only oil of 7¼ poises, but also an oil of 5 poises and another of 21.

In making comparisons with these three oils, all varnishes of the same reduction were flowed crosswise on clean tin panels, 3¾ by 10½ in. The fatty edge of the tin was wiped off before the varnish had set to prevent the formation of an extremely thick film. These tins were then bent over a ⅛-in. rod in the usual manner. I found that it required the same percentage of 5, 7¼ and 21 poise oils to bring the elasticity to a point where it would not crack when bent over the rod.

The object of flowing the three varnishes on the same panel, crosswise, was to insure absolutely similar conditions on all three varnishes, which I presumed might not be absolutely true if the varnishes had been flowed on 3 by 5 in. panels as specified in the present Kauri test.

From my work on using oils of different viscosity, I would conclude that the viscosity variation of the oil used for this test could be widened considerably, and for my part, I would recommend a viscosity of 8 poises or minus 2.

GROUP 3.—HARDNESS OF VARNISH FILMS

L. L. Steele, chairman, has been considering the hardness of varnish films and reports that a prerequisite for the work of his group is a control room or cabinet in which the temperature and humidity can be kept constant or varied at will. Until such equipment is available, the members of this group will find it difficult to make progress.

GROUP 4.—STANDARDIZATION OF SERVICE TESTS FOR EXTERIOR VARNISHES

H. A. Gardner, chairman, reports the results of Exposure Tests of Varnishes on surfaces of glass, wood, black iron and black japanned steel. They show the prominent part played by the surface coated in the durability of finish, and indicate that wood and glass are unsatisfactory surfaces for such tests. Further work will be necessary before a satisfactory method can be adopted.

This group during the past year has been working on standardization of service tests with exterior varnishes. Information submitted to the members of the committee, together with samples of varnishes and test panels, is given in the 1925 report of the committee.[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, pp. 234, 235 (1925).

The panels were exposed on April 1, 1925. Only two members of the group regularly reported the results of frequent inspections. All four members, however, reported the final results as obtained on October 1, 1925. There is, therefore, presented an abstract of the August and September reports of the two members who reported frequent inspections and additional charted results of all four observers as of October 1, 1925 (Table I).

Conclusions from Booge and Gregory.—

Method of application: Comparing the brushed, sprayed, and dipped Japan panels, the sprayed panel gives the best results with the brushed panel second and the dipped panel third. This conclusion relates to the quickness of checking and final deterioration.

Panel Material: The japanned panels gave the quickest checking; the steel panels were second; the maple panels were third; and the glass panels, fourth.

Varnishes: Of the three varnishes tested, No. 3 had the best life, No. 2 next best, and No. 1 the poorest.

Ease of Examination: The man who read the checking on these panels tells me that the black japanned panels were the easiest on which to observe the checking; that the steel panels were second; the maple panels, third; and the glass panels, fourth. This last was due to the fine checking occurring on the glass panels.

Rusting: The steel panels were, of course, the worst in this respect, the japanned panels showing very little rusting. We have found in other tests that it is inadvisable to use panels without any undercoats, due to the fact that they sometimes rust through before they check.

Adhesion—Peeling: The black panels showed the first peeling, but the glass peeled the worst. The wooden panels showed the best adhesion, with steel second. In comparing the adhesion of the japanned panels alone, the brushed coats appear to be the poorest, the dipped coats second, and the sprayed coats the best. The three varnishes did not behave the same over different materials in this respect. On steel, No. 3 varnish was the worst, while on the japanned panels, No. 1 was the worst; and on the glass panels No. 2 was the worst, with No. 1 second.

Final Conclusions: Taking into consideration the ease of preparation of the panel, the ease of reading the panels without rust interfering and the ease of duplicating the panels themselves, we find that the black japanned panels are preferable. Although the sprayed panels appeared to give the best results, the dipped panels were very good and are the simplest to prepare. With steel, rust interferes with the checking. With wooden panels, it is difficult to obtain the same grade of wood at different periods and in different panels, and with the glass panels the peeling is the principal objection. The japanned panels can be easily duplicated, are simple to prepare, will in most cases outlast the top coat, and are easy to read. The peeling observed on the black japanned panels we have not found to be universal, as we have results on the roof where the varnishes have checked to the point of requiring a microscope to read them without any peeling whatever.

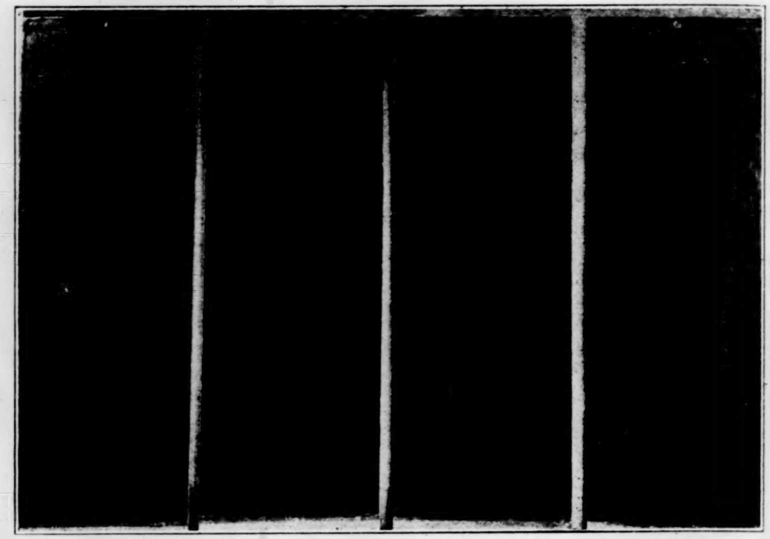

FIG. 1.—Photograph of Japanned Panels in Washington Tests—H. A. Gardner, Observer.

Some of the black japanned panels showing the characteristic scaling of varnish. Photograph made on July 20, 1925.

FIG. 2.—Photograph of Panels in Washington Tests—H. A. Gardner, Observer.

Large panel on left is of glass. Note almost entire scaling of varnish from surface. Panel in middle is of maple wood. Note the decayed and checked surface of varnish. Next panel is of steel. Practically no defects shown. Last panel is of black japan. Note scaling and disintegration of varnish. Photograph made October 1, 1925.

Conclusions from E. G. Richardson.—From the October inspection, it appears that the black iron panels offer the best foundation for testing varnishes, but the November 1 inspection shows rusting to have progressed very fast during the thirty-day period. I question, therefore, if the conclusion is entirely correct.

The exposure of the panels was continuous up until December 31, 1925. Panel 3M1 showed deeply longitudinal crazing but the varnish film was intact over most of the panel. Panel 3M2 showed fine checks. Moisture had come through and destroyed the film in spots. Panel 3M3 showed dense, fine checks, with film raised on most of the panel.

On japanned panels, the varnish films had completely disappeared on all but a few, and in these cases the films were badly lifted. Possibly severe moisture conditions in Detroit at the start of the tests were responsible.

All varnish films had completely disappeared from the glass. The black iron panels showed severe rusting over entire surface. All black iron panels showed possibilities in early stages, but rating of varnish films was interfered with by rusting before completion of test. Further work might be done on corrosion resisting metals.

Remarks from H. R. Johnston.—On the maple panels it was found difficult to determine the degree of checking. On the iron panels long lines, appearing like scratches, were visible to the naked eye. Under the microscope, these scratches showed as long, fine checking. Moreover, a comparison of the tests was very hard to make on the glass panels. On the brushed, black japanned panels very bad lifting of the film with generally poor appearance was shown where varnish No. 2 was used. On varnish No. 3, slight lifting and pulling, in addition to bad checking was indicated. On the sprayed black japanned panels, some lifting was shown. On the dipped black japanned panels, bad wrinkling at the edges and slight lifting and checking was shown.

Conclusions of Gardner and Parks.—It is our conclusion that of the various types of panels used, the black iron panels are the most satisfactory. They show less checking and scaling than any of the other panels experimented with. It is also our conclusion that the glass panels are the least satisfactory. Much scaling was shown on them, and inspection was very difficult. The maple panels were unsatisfactory. In fact, panels of any wood may be unsatisfactory, as they are difficult to obtain of uniform grade. Being porous, they naturally require filling with varnish before satisfactory surfaces for the final coats can be obtained, and a long period is required to build up the panels for exposure. We have generally observed difficulty in obtaining uniformity of results with the same varnish on different panels of the same wood.

The plain steel panels used were the only ones that showed fairly good agreement in results with the same varnish upon duplicate panels. Less peeling, scaling and checking was shown upon these plain steel panels than upon any other type used. It is our conclusion, therefore, that they are the most satisfactory to use for making varnish exposure tests. They are easily obtained of uniform size, and require no previous treatment, except cleaning with solvent.

General Conclusions.—The above reports are in agreement in the elimination of glass and wood panels. Black japan and black iron panels give the more consistent results. Black japan panels show a lack of adhesion between the surface and the varnish which might be overcome by baking the japan at a lower temperature. On long exposure black iron panels show a tendency to rust which interferes with inspection. In view of this it is suggested that further work be done by the group during the coming year on exposure tests of varnishes on corrosion resisting metals such as stainless steel and various grades of steel and iron which may be more resistant to corrosion than ordinary soft steel.

GROUP 5.—INVESTIGATIONS OF TESTS FOR WORKING PROPERTIES

This group has been discharged.

GROUP 6.—DETERMINATION OF ACID VALUE AND ITS INFLUENCE IN THE THICKENING WITH ALKALINE PIGMENTS

H. A. Nelson, chairman, reports comparative results on six proposed methods for determining acid number. In the study of methods for determining acidity of varnish products, five operators have cooperated by making acid number determinations on eight samples of bodied oils and varnishes.

The samples used were as follows:

Varnish No. 9—1. Heat bodied linseed oil, medium viscosity.

Varnish No. 9—2. Heat bodied - air blown linseed oil of high viscosity.

Varnish No. 9—3. A rosin-tung oil varnish, in which the rosin has been neutralized with 5 lb. of lime to 100 lb. of rosin.

Varnish No. 9—4. A rosin-tung oil varnish in which 7 lb. of lime have been added to each 100 lb. of rosin.

Varnish No. 9—5. Damar varnish, in which the damar gum has been cut in mineral spirits.

Varnish No. 9—6. An ester gum-tung oil varnish.

Varnish No. 9—7. Conge-linseed oil varnish.

Varnish No. 9-8. A long oil linseed oil-tung oil rosin varnish in which the rosin was neutralized under heat with 10 per cent of zinc oxide. No lime was used. It contains approximately 29.6 per cent of tung oil and 11 per cent of rosin. The latter was neutralized to the extent of 80 per cent with zinc oxide and litharge plus a trace of manganese.

The methods by which the above samples were tested are as follows:

Method I.—The alcoholic method as described in Section 3 in the A.S.T.M. Tentative Specifications for Soya Bean Oil Raw or Refined (D 124 – 22 T)[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 748 (1922); also 1925 Book of A.S.T.M. Tentative Standards, p. 274.

Method II.—The alcohol-benzol method as described in Section 3 of A.S.T.M. Tentative Specifications for Raw Tung Oil (D 12 – 23 T)[1]

Method III (suggested by E. A. Stoppel).—*Materials.*—Weight of sample taken, 10 g. Volume of ether, U.S.P., 100 cc. Alcoholic KOH or NaOH 0.5 *N*. Indicator 1 per cent alcoholic phenolphthalein.

No heating is required for solution, although 2 to 5 minutes with shaking is usually allowed for complete solution. Titration with shaking is continued until a pink color is reached. If the acid number of the varnish is very high, 0.2 *N* alkali is recommended. The method, of course, is applicable to oils and resins as well as varnish.

Method IV (suggested by M. Neidle).—Applicable to materials whose color will not mask the phenolphthalein end point.

To a suitable weight of sample in a 300 to 500-cc. Ehrlenmeyer flask add 50 cc. of benzol or xylol. Mix until uniform, heating if necessary.

Add 50 cc. neutralized denatured alcohol, and titrate with approximately 0.5 *N* aqueous NaOH, using phenolphthalein as indicator. If more than 25 cc. of NaOH has been used, add 50 cc. more of neutralized denatured alcohol and continue the titration until, after shaking, the color persists for at least two minutes. Vigorous shaking during titration is essential for the proper distribution of the acid.

When the final end point is taken, the volume of alcohol should be twice that of the water in the mixture.

Method V.—Applicable to materials whose color would ordinarily mask the phenolphthalein end point, for example, asphaltum varnishes, cotton pitches, very dark gum goods; also useful where metallic soaps are precipitated when alcohol is added.

To a suitable weight of material, add 50 cc. of benzol or xylol. Mix until uniform, heating if necessary. Then add 50 cc. of carbon tetrachloride, a mixture of 50 cc. of neutralized denatured alcohol and 10 cc. of water, ½ teaspoonful of sodium chloride and a little phenolphthalein indicator. After mixing well, a clear layer should quickly separate on top.

Now, titrate with 0.5 *N* aqueous NaOH, with vigorous shaking until, on standing, the top layer is pink and remains so for at least two minutes.

If more than 15 cc. of NaOH has been used, add 50 cc. more of neutralized denatured alcohol, shake, and continue the titration if the color has been discharged. When the final end point is taken, the total volume of alcohol should be at least twice that of the water in the mixture.

A first determination may be over-stepped and brought back with 0.5 H_2SO_4. The second determination should then give a sharp end point within one or two drops of the alkali.

NOTE.—The purpose of the carbon tetrachloride is to obtain a solvent layer of high specific gravity. Water is added to the alcohol to destroy the miscibility of the latter with the ether solvents present. The sodium chloride reduces the tendency towards emulsification.

A sixth method, which is a slight modification of a method used by Gardner and Coleman,[2] was tried in one laboratory, where it has been used, as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 644 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 266.

[2] See Paint Manufacturers Association *Circular No. 87*, February, 1920.

TABLE II.—COMPARATIVE RESULTS WITH VARIOUS METHODS OF DETERMINING ACID NUMBER.

Sample	Method I			Method II			Method III					Method IV					Method V					Method VI	
	Ingalls	Nelson (Wien)	Steele	Ingalls	Nelson (Wien)	Steele	Bins-wanger	Howe	Ingalls	Nelson (Wien)	Steele	Bins-wanger	Howe	Ingalls	Nelson (Wien)	Steele	Bins-wanger	Howe	Ingalls	Nelson (Wien)	Steele	Nelson (Wien)	
9—1	7.6	7.9	8.6		8.1	8.3				8.4	8.3				8.2	8.4				8.1	8.2	8.5	
	7.6	8.1	7.8		8.1	8.4	8.43			8.3	8.3	8.34			8.3	8.3	8.45			8.2	8.2	8.5	
	7.6	8.0	8.2	8.3	8.1	8.4	8.44	8.05	8.2	8.4	8.3	8.51	8.07	8.4	8.3	8.4	8.40	8.06		8.2	8.2	8.5	
9—2	7.4	7.8	10.0		7.6	9.4				8.4	8.9				8.0	9.2				7.8	7.6	8.1	
	7.9	7.6	9.4		7.7	8.7	8.25			8.3	9.9	8.01			7.7	7.5	8.02			7.8	7.3	8.3	
	7.6	7.7	9.7	7.6	7.6	9.1	8.20	8.32	8.8	8.4	9.5	8.03	8.71	7.5	7.9	8.4	8.02	7.72		7.8	7.5	8.2	
9—3		33.1	35.8		35.9	35.5				35.9	37.0				35.7	36.2				34.8	35.8	35.6	
		32.4	36.3		36.1	35.7	37.30			35.5	36.4	35.60			35.3	36.8	35.40			34.2	35.4	35.5	
	35.9	32.7	36.1	36.2	36.0	35.6	37.50	34.09	36.3	35.7	36.7	35.45	34.32	36.4	35.6	36.5	35.40	34.14		34.5	35.6	35.6	
9—4		26.5	31.8		30.6	30.4				31.2	31.5				30.4	30.9				29.5	30.4	30.2	
		25.9	31.5		30.8	31.1	31.70			31.4	32.2	30.19			30.5	30.9	30.30			29.6	30.4	30.6	
	26.8	26.2	31.7	31.1	30.7	30.8	31.90	28.81	31.4	31.2	31.9	30.22	29.35	30.9	30.5	30.9	30.24	28.72		29.6	30.4	30.4	
9—5		15.7	16.9		16.7	16.9				16.8	17.2				17.0	17.3				16.7	16.7	17.1	
		16.3	16.6		16.9	16.8	17.74			16.6	17.3	16.60			17.0	17.2	16.70			16.7	16.7	17.3	
	16.4	16.0	16.6	16.3	16.8	16.9	17.80	16.98	16.7	16.7	17.3	16.54	17.05		17.0	17.3	16.65	16.5	16.8	16.8	16.7	17.2	
9—6		5.7	6.9		7.3	7.4				7.7	7.7				7.6	7.6				7.0	7.1	7.4	
		5.6	7.3		7.2	7.4	8.71			7.7	7.7	7.44			7.6	7.6	7.28			7.0	7.3	7.4	
	5.9	5.7	7.1	7.5	7.3	7.4	8.69	7.7	7.3	7.7	7.7	7.40	7.6		7.6	7.6	7.30	7.4	7.3	7.0	7.2	7.4	
9—7		14.3	17.1		16.3	16.9				16.7	17.0				16.7	16.9				16.8	16.7	17.0	
		14.5	17.0		16.4	16.9	18.51			16.5	17.0	17.30			16.6	17.0	17.01			16.4	16.7	16.7	
	15.2	14.4	17.1	16.1	16.4	16.9	18.50	16.6	16.7	16.6	17.0	17.29	16.5		16.7	17.0	17.00	16.82	16.8	16.6	16.7	16.9	
9—8		12.3	14.3		19.1	18.4				19.8	20.3				18.9	18.5				18.6	18.8	14.5	14.3
		12.1	13.9		19.0	18.5				19.5	20.3				18.4	18.6				19.8	18.5	14.2	14.1
		11.4																					
	10.6	11.9	14.1	18.6	19.0	18.5			19.2	19.7	20.3				18.6	18.6			18.8	18.8	18.7	14.4	14.2

Method VI.—Weigh a sample of the oil into a dry clean flask. Add 75 cc. of a mixture of three parts ethyl alcohol and one part benzol. Boil gently for one minute.

Cool to room temperature, add a few drops of phenolphthalein indicator and titrate with 0.1 *N* alcoholic KOH. Agitate thoroughly during titration. When the pink color appears, stopper the flask and shake. The end point is reached when the pink color persists after one-half minute.

The results available to date are given in Table II.

The following comments on the nature of the end points obtained are offered by Mr. Wien, representing H. A. Nelson:

Method I.—	Sample No. 9—1	Good.
	Sample No. 9—2	Poor.
	Sample No. 9—3	Fair (faded and oil gelatinized on bottom of flask).
	Sample No. 9—4	Fair (faded and oil gelatinized on bottom of flask).
	Sample No. 9—5	Good.
	Sample No. 9—6	Fair (fades and oil gelatinized on bottom of flask).
	Sample No. 9—7	Poor (fades and oil gelatinized on bottom of flask).
	Sample No. 9—8	Poor (fades and oil gelatinized on bottom of flask).
Method II.—	Sample No. 9—1	Good.
	Sample No. 9—2	Poor (yellow color).
	Sample No. 9—3	Fair (fades and not clear).
	Sample No. 9—4	Fair (fades and not clear).
	Sample No. 9—5	Good.
	Sample No 9—6	Fair (fades and not clear).
	Sample No. 9—7	Poor (fades badly and not clear).
	Sample No. 9—8	Fair (fades and not clear).
Method III.—	Sample No. 9—1	Good.
	Sample No. 9—2	Not very clear.
	Sample No. 9—3	Good.
	Sample No. 9—4	Not clear.
	Sample No. 9—5	Not clear.
	Sample No. 9—6	Poor (dark color).
	Sample No. 9—7	Good.
	Sample No. 9—8	Fair (fades and not clear).
Method IV.—	Sample No. 9—1	Good.
	Sample No. 9—2	Poor (too yellow).
	Sample No. 9—3	Good.
	Sample No. 9—4	Fair (fades and not clear).
	Sample No. 9—5	Good.
	Sample No. 9—6	Good.
	Sample No. 9—7	Fair (fades and not clear).
	Sample No. 9—8	Clear end point but of short duration. Final taken at 30 seconds.

Method V.—	Sample No. 9—1	Good.
	Sample No. 9—2	Good.
	Sample No. 9—3	Good.
	Sample No. 9—4	Good.
	Sample No. 9—5	Good.
	Sample No. 9—6	Good.
	Sample No. 9—7	Good.
	Sample No. 9—8	Good.
Method VI.—	Sample No. 9—1	Good.
	Sample No. 9—2	Good.
	Sample No. 9—3	Good (gelatinized but did not adhere to the flask; could be broken up by shaking).
	Sample No. 9—4	Good (gelatinized but did not adhere to the flask; could be broken up by shaking).
	Sample No. 9—5	Good (gelatinized but did not adhere to the flask; could be broken up by shaking).
	Sample No. 9—6	Good (gelatinized but did not adhere to the flask; could be broken up by shaking).
	Sample No. 9—7	Good (gelatinized but did not adhere to the flask; could be broken up by shaking).
	Sample No. 9—8	Good end point, but gelatinized on the bottom of the flask, which probably accounts for low results.

From these results and observations it would be difficult to choose between Method III and Method IV. The methods check each other very satisfactorily and each seems to give entirely concordant results in the hands of different operators. Method V is especially desirable on account of the good end points obtained, but the results by this method on sample No. 9—2 (heavy air-bodied linseed oil) appear to be slightly low, although they check very well as between different operators. Method II shows good checks throughout considering the fugitive nature of the end points. Method I is entirely out of the question.

In accordance with action taken by Sub-Committee IX, at its meeting held in Brooklyn, N. Y., March 9, 1926, the Linseed Oil Addition Test for Elasticity or Toughness is recommended for adoption as a Tentative Method for Testing Oleo-Resinous Varnish.

Respectfully submitted on behalf of the sub-committee,

E. J. COLE,
Chairman.

K. J. HOWE,
Secretary.

REPORT OF SUB-COMMITTEE XIV ON PREPARATION OF IRON AND STEEL SURFACES FOR PAINTING

The sub-committee held a meeting at Altoona, Pa., on October 15, 1925, Messrs. B. D. Jennings, M. E. McDonnell, R. E. Rogers, A. H. Sabin and the undersigned being in attendance.

The test panels which were originally exposed in 1917 were examined in their position on the roof of the Pennsylvania Railroad paint shop building and rated as follows:

		Condition Rating per cent	
Panel	Surface Condition or Treatment Before Painting	October 15, 1925	February 27, 1925
	New Steel Panels		
No. 1	Clean surface, mill scale intact, painted in warm dry room	10	20
No. 2	Mill scale broken, some rust, hand cleaned, painted in warm dry room	25	40
No. 3	Sand-blasted, painted immediately after in warm dry room	80	85
No. 4	Sand-blasted, heated in oven to 225° F. and then painted	35	65
No. 5	Sand-blasted, placed in cool damp room 40 minutes and then painted	84	87
No. 6	Sand-blasted, placed outdoors and painted there at a temperature of 25 to 27° F.	84	85
No. 7	Sand-blasted, exposed out of doors for 7 days, painted over rust in warm dry room	55	70
No. 8	Pickled, painted in warm dry room	84	87
No. 9	Pickled, exposed out of doors 7 days, painted over rust in warm dry room	50	70
No. 10	Exposed to weather 6 months, cleaned with wire brush and scraper	15	none made
No. 10-A	Former Brooklyn panel No. 10 re-prepared by sand-blasting one-half surface, hand cleaning the other half of same, painted June 13, 1921.		
	Sand blast side	95	95
	Scraped side	70	75
No. 11	Pickled, painted in warm dry room	88	90
No. 16	Incompletely sand-blasted, painted in warm dry room	45	60
	Old Steel Panels		
No. 12	Cleaned with wire brush only	82	85
No. 13	Cleaned with benzine, scraper and wire brush	68	70
No. 14	Benzine applied over rust spots and burned off with torch, then cleaned with scraper and wire brush	80	80
No. 15	Sand-blasted	73	75

As will be noted by comparison of the ratings with those of the previous inspection dated February 27, 1925, there was a very marked advance in the failure of the coating on some of the panels, especially sand-blasted panels Nos. 4 and 7, pickled panel No. 9 and incompletely sand-blasted panel No. 16. Sand-blasted panel No. 3, which was later removed from the test for retreating, showed evidence of the commencement of rapid deterioration. It should also be noted that panel No. 10, which was considered to have failed some years ago, had not progressed in deterioration as rapidly as some others and was rated better than panel No. 1; however, the corrosion on panel No. 10 was much deeper than on panel No. 1.

Panels Nos. 1, 2 and 3 were removed from the test rack and re-prepared for test, each being divided longitudinally in three sections, each approximately 1 ft. wide. One end section of each panel was sand-blasted on the test side and the remainder of the surface was then wire-brushed, being gone over once with a coarse brush and once with a fine brush and then dusted. The time of brushing and dusting did not exceed 2 minutes for each panel. The end section opposite the one sand-blasted was then washed with benzine and a gas torch applied to the surface until the benzine was burned or driven off; the entire surface of this end section of panels Nos. 1 and 2 was washed with the benzine before applying the torch but on panel No. 3 the paint coating was so generally intact that the benzine was applied only to the rusted edges and the few rust spots on the interior after which the torch was likewise applied. No benzine was applied to the sand-blasted end sections nor to the wire-brushed middle sections.

The panels were then painted with one coat of paint mixed from some of the original lot of paint paste furnished for the original tests, this paste having been preserved. The paste was thinned in the same proportion as the original paint using in place of the No. 1 Japan drier equal parts of drier and turpentine thinner of the kinds in use in the shop. The hand cleaning and painting was done by Mr. Meyer who painted the original panels, a painter of great experience. The paint, can and brush were weighed before and after painting each panel so as to determine the spreading rate. The weights were recorded as follows, Troy measurement:

Before	painting	panel	No. 1......	10¾ oz.	4 dwt.	(equals 219 dwt.)
After	"	"	No. 1......	9 oz.	no "	(" 180 ")
"	"	"	No. 2......	7¼ oz.	2¾ "	(" 147¾ ")
"	"	"	No. 3......	5¾ oz.	4 "	(" 118¾ ")

The respective weights of paint used on the panels may be calculated from these weights as follows:

Panel No. 1	39	dwt.
" No. 2	32¼	"
" No. 3	29	"

The panels received the second coat on October 16, panel No. 1 received 1.7 oz., panel No. 2, 1.54 oz., and panel No. 3, 1.23 oz., avoirdupois (not Troy) while the weight of the paint was found to be 12½ lb. per gal.

The hand cleaning and painting was done inside one of the Pennsylvania Railroad shop buildings and the panels were left to dry therein in a warm dry atmosphere.

The retest panels (Nos. 1, 2 and 3) were placed on the test rack in original locations on October 26, 1925.

Respectfully submitted on behalf of the sub-committee,

A. W. Carpenter,
Chairman.

REPORT OF SUB-COMMITTEE XV ON SPECIFICATIONS FOR PIGMENTS DRY AND IN OIL WHEN MARKETED IN THAT FORM

The sub-committee has discussed the tentative specifications for pigments under its jurisdiction. It is recommending the revision of the following specifications as indicated and their advancement to standard in their proposed revised form:

Tentative Specifications for Lithopone (*D 208 – 25 T*).[1]—

Section 3 (*b*).—Change the requirement for maximum zinc oxide from 1.0 per cent to 2.0 per cent.

In the same section, change the last line of the table to read as follows:

"Barium sulfate......................98 per cent of the remainder."

Tentative Specifications for Lampblack (*D 209 – 25 T*).[2]—

Section 3.—In Paragraphs (*c*) and (*d*), omit the requirement for maximum pigment (40 per cent) and for minimum oil (or vehicle) (60 per cent).

Tentative Specifications for Bone Black (*D 210 – 25 T*).[3]—

Section 3.—In Paragraph (*b*) change the requirement for ash to read as follows:

"Ash, maximum, per cent of pigment dried at 105° C..........88.0"

In Paragraphs (*c*) and (*d*) omit the requirements for maximum pigment (55 per cent) and minimum oil (or vehicle) (45 per cent).

The sub-committee is also recommending the revision of the following specifications as indicated and recommends that as revised they be continued as tentative for another year:

Tentative Specifications for Chrome Yellow (*D 211 – 25 T*).[4]—

Section 2 (*a*).—Change to read as follows:

"*Dry Pigments.*—The dry pigments shall be chemical precipitates consisting of normal or basic lead chromates or mixtures of these with or without admixtures of other insoluble compounds of lead, but without any other admixtures."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 648 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 286.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 650 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 288.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 652 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 290.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 654 (1925); also 1925 Book of A.S.T.M Tentative Standards, p. 292.

Section 3.—Change Paragraph (*b*) to read as follows:

"The dry pigments shall meet the following requirements:

Total matter soluble in water, maximum, per cent	0.5
Total of all substances other than insoluble compounds of lead, maximum, per cent	3.0
Organic colors or lakes	None
Coarse particles (total residue on a No. 325 screen), per cent, not over	1.0"

Change the second paragraph of Paragraph (*c*) to read as follows:

"The pastes shall meet the following requirements:

Pigment, minimum, per cent	75
Linseed oil, maximum, per cent	25
Water and other volatile matter, maximum, per cent	0.7
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	1.5"

Change the table of requirements in Paragraph (*d*) to read:

"Pigment, minimum, per cent	70
Vehicle (japan), maximum, per cent	30
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of pigment	1.5
Non-volatile matter in the vehicle, minimum, per cent of the vehicle	40"

Physical properties and tests, particularly tinting strength, are considered a better measure of value than percentage of lead chromate.

Tentative Specifications for Pure Chrome Green (*D 212 – 25 T*).[1]—

Section 2 (*a*).—Change the word "co-precipitated" to "precipitated."

Section 3.—In Paragraph (*b*) change the first line of the table of requirements to read as follows:

"Percentage of total lead present in the form of chromate, minimum, 70"

In Paragraph (*c*) change the table of requirements to read as follows:

"Pigment, minimum, per cent	70
Linseed oil, maximum, per cent	30
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	1.5"

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 656 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 294.

In Paragraph (*d*) change the table of requirements to read as follows:

"Pigment, minimum, per cent	65
Vehicle (japan), maximum, per cent	35
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	1.5
Non-volatile matter in the vehicle, minimum, per cent of the vehicle	40"

It is pointed out that chrome green cannot be made by any process which could strictly be called "co-precipitation."

Tentative Specifications for Reduced Chrome Green (D 213 – 25 T).[1]—

Section 2 (a).—Change the word "co-precipitated" to "precipitated."

Section 3.—In Paragraph (*b*), change the percentage of total lead present in the form of chromate from 75 minimum to 70 minimum. Change the maximum percentage of calcium oxide from 0.5 to 1.0.

In Paragraph (*c*) change the table of requirements to read as follows:

"Pigment, minimum, per cent	80
Linseed oil, maximum, per cent	20
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	2.0"

In Paragraph (*d*) change the table of requirements to read as follows:

"Pigment, minimum, per cent	75
Vehicle (japan), maximum, per cent	25
Coarse particles and skins (total residue retained on a No. 325 screen), maximum per cent	2.0
Non-volatile matter in vehicle, minimum, per cent of the vehicle	40"

The sub-committee has at present no new work laid out. Previous discussion of various pigments not now covered by specifications, indicated that the variety of conditions is too great and the need of specifications too small to warrant writing them.

Respectfully submitted on behalf of the sub-committee,

H. E. SMITH,
Chairman.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 658 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 296.

REPORT OF SUB-COMMITTEE XVIII ON PHYSICAL PROPERTIES OF PAINT MATERIALS

Sub-Committee XVIII is first mentioned in the Proceedings in 1916[1], in the following words: "A special sub-committee has just been appointed to advise the whole committee on the practicability of plans for a systematic study of the physical problems connected with paints. It is hoped and believed that this special sub-committee will be able to suggest work on entirely new lines which will lead to important results."

In view of the fact that the work has been of such a nature that it could not always be reported in terms of definite accomplishment, and since repeated reports of "progress" usually mean either dismal failure or moribund inactivity, a short review of the sub-committee's activities to date will not be out of place here, and will be of material assistance to the whole committee in taking action on certain changes in plan and scope which the sub-committee chairman will suggest.

Soon after appointment the sub-committee started a preliminary consideration of the color and optical properties of pigments and vehicles, but, as available optical instruments were few, and such work was not well adapted to cooperative committee work, the chairman sought for some qualified worker already in the field, and was fortunate in finding in Mr. H. E. Merwin an investigator fully capable and willing to undertake the task. Those who recall his classic paper "Optical Properties and Theory of Color of Pigments and Paints" published in 1917[2] will appreciate the thorough and fundamentally important nature of that work.

About that time there appeared in a certain section a growing tendency to include a viscosity requirement in paint specifications as a means of controlling the consistency. Despite the experience of Committee D-1 with the viscosity measurements made on the paints applied to the Arlington Test Fence,[3] it had not become widely recognized that "body" or "painting consistency" in a two-phase system such as paint, differs materially from the simple viscosity of a single-phase liquid, even though Maxwell had long before pointed out the difference between viscosity and plasticity. Accordingly the sub-committee directed its attention to finding some means of quantitative measurement of consistency, more definite and more accurate than the crude qualitative methods in universal use. Here again unusual apparatus, and technique rendered cooperative committee work impracticable, and again the chairman sought help from the outside. After some search for the right man the facts were laid before Mr. E. C. Bingham, an acknowledged authority on the laws of plastic flow, and he not only manifested immediate interest but also agreed to put a qualified operator on the work at once if the committee could furnish money for the necessary expenses. There were no funds available and, for a time, the matter rested. In a short time, however, the New Jersey Zinc Co., in the person of Mr. F. G. Breyer, a member of the sub-committee, offered cooperative assistance which eliminated the necessity of funds from the committee, and the work went forward. By the middle of 1919 the development of the plastometer, by Bingham and Green had become an accomplished fact which demonstrated that paint was a plastic solid rather than a viscous liquid.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XVI, Part I, p. 272 (1916).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XVII, Part II, p. 496 (1917).

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 424 (1913).

Because of certain apparent limitations, and high cost, the industrial application of the plastometer in the paint industry has been slow and even halted. As yet however nobody has arisen to show clearly that the theory or principles involved are unsound or necessarily inadequate, and personally, the chairman of this sub-committee holds the firm conviction that, with almost any type of paint called for, the plastometer may be used to insure deliveries of a consistency well within the limits allowable for sound practice in application. Be that as it may, many members of the sub-committee felt that it could add little or nothing constructive to the situation as it then stood, and accordingly the sub-committee's attention was once more turned to the question of color.

In the paint industry there has never been any need for argument over the desirability of some practical method of measuring color, but the difficulties experienced by the various branches of the U. S. Service during the World War in obtaining uniform shades, especially of olive drab in paints and khaki in textiles, emphasized pointedly the virtual necessity of some method of defining color standards in quantitative terms, and it was along this direction that the committee started out on what has proved to be a long and arduous task.

The preliminary work involved a study of the various systems and methods already suggested which had advanced to a stage of availability through actual or limited use, and from early in 1920 to well into 1922, systems involving both primary and secondary reference standards were studied, compared and tested. Some of these showed a considerable practical utility but none of them fulfilled the requirements held to be necessary; the instruments were comparators rather than analyzers; difficulties of a serious kind were encountered in maintaining the integrity of the reference standards, either in preservation or replacement; none of them either measured or recorded color in terms of fundamental physical units; nor did they offer any hope that we could ever be relieved of the burden of the wet sample as the only criterion of accuracy, imperfect as it may often become on even short periods of storage. In view of these findings, with some other considerations, it was finally decided that the committee, in any further work, should confine its study to only those instruments which would permit the analysis of a color or colored surface into its fundamental characteristics or attributes. In accordance with this decision the spectrophotometer was selected for trial, and a series of tests planned, in order to determine its usefulness for the purpose, and its limitations.

This decision was greatly strengthened by the report of the Colorimetry Committee of the Optical Society of America. A reprint of this report from the Journal of that society[1] carries the following relevant paragraph:

> "The characteristics of physical objects, which determine their colors when viewed by radiation from other sources, can be expressed almost completely by means of spectral reflection or transmission curves, representing as a function of wave-length or frequency, the fraction of the original radiation impinging upon the object, which leaves it as reflected or transmitted rays, respectively. Such curves are most readily determined by means of a spectrophotometer."

It also contains the following:[2]

> "*Spectrophotometry.*—A method of specifiying the physical characteristics of objects and samples of radiation, for the purposes of colorimetrics, which is actually independent of the observer is found in various applications of spectrophotometry or spectroradiometry. . . . On the side of the stimulus, pure and simple, spectrophotometry is the fundamental method of colorimetric specification. All other methods (except spectroradiometry) fail to give an equally complete account of the stimulus characteristics."

In view of such unequivocal statements from such an authoritative source it seemed that the way should be easy—a mere matter of a few details in adaptation. As a matter of fact it was here that our real troubles began, for, aside from the fading of some of our early samples under the strong illumination employed in our instruments, there were discrepancies in results that could not be explained by any facts within our knowledge at that time. Different instruments, for instance, although apparently carefully calibrated, would not check even on identical samples; different operators working with the same type of instrument and sample did not check; in fact even the same operator with the same instrument and sample could not be sure of getting identical readings in a series of tests made at intervals over a period of time. It was soon noted, too, that silk ribbon, with satin finish on one side and ribbed on the other, gave higher reflective value on the satin, or gloss, side, than on the dull, or ribbed, side, although the threads were demonstrably uniform in color throughout, while in the case of paints, flat paints gave a higher reflection value than the same paints varnished with a thin coat of varnish that was shown to be optically colorless under the conditions of observation.

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[1] *Journal*, Am. Optical Soc., Vol. VI, No. 6, August, 1922, p. 566.

[2] *Ibid.*, p. 574.

More information was needed, and, beginning in 1922, extending through 1923 well into 1924, the sub-committee subjected itself to the mechanical drudgery of collecting, preparing, and analyzing a large number of colored materials of different sorts, for the purpose of securing a mass of data from which conclusions might be drawn and which would serve as a basis for discussion on the accuracy of the instruments at our disposal and their ability to closely determine the reflection characteristics of colored surfaces. In this work the materials tested were linoleum, paper, silk (satin finish on one side and ribbed on the other), leather, and paints (gloss and flat). In all about 2000 curves were plotted, involving separate recorded readings running in number to well over 250,000, as estimated from our records, and probably many thousands more not traceable.

In this period new members were added to the sub-committee to secure more instruments and additional technical skill; Mr. Paul had become the willing and highly efficient secretary; Mr. G. W. Thompson's technical paper on "Color" was presented before the Society[1], and in cooperative work we had the Bureau of Standards, deeply interested in our work from the beginning, Mr. Keuffel, designer of the Kueffel & Esser Color Analyzer, and Mr. William F. Little of the Electrical Testing Laboratories, later an official member of the committee.

Up to this time the work had been carried on by means of correspondence, and conferences between such active members as could meet without heavy expense in time and money, because the geographical distribution of the committee was too wide to permit full attendance at formal meetings. With the large mass of material at hand, however, which had been compiled by Mr. Paul and put into suitable form for study and comparison, it was obviously time to call a formal meeting of the committee for the purpose of full and free discussion, and to receive suggestions and recommendations for such further procedure as might seem advisable. Accordingly, a meeting was held in Brooklyn on September 15, 1924, at which all the active and interested members were present or represented. After some four hours of study and discussion, it was decided that, although the curves showed many discrepancies for which there was no ready explanation, there was sufficient concordance to indicate that further perseverance might lead to something definite.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 396 (1923).

As a result of this meeting it was agreed that a very carefully prepared set of ten colored samples of paints should be sent to the members, together with material and extended instructions for the more exact calibration of the instruments available, to the end that a higher degree of accuracy might be attained on the new samples. As a further precaution against possible change with age of the samples it was agreed to have the analyses made on a fixed date, December 9, 1924. Seven members received complete sets of material, instructions and samples, and the analyses were duly carried out according to agreement. These 70 curves, representing a minium of 9800 readings, were compiled in a form suited to a careful comparison of the results—and the discrepancies were still there. However, we were getting nearer, and it was noted that intensity factors at certain wave lengths, as obtained by different observers, showed marked discrepancies due in part to inaccuracies in the instruments used. These instruments were later changed, in certain minor details, in an endeavor to counteract these defects.

In the report of the sub-committee to the general committee at its meeting April 10, 1925, a more detailed account of the work on this last set of samples was presented, together with a full set of the curves showing just how far concordance was lacking.

Mr. Little, who had devoted much time to a careful study of the situation, called the attention of Mr. Paul to certain differences made manifest by a comparison of the analyses on spectrophotometers carrying different types of illuminating equipment, with results of analyses by the sphere method. He found, after plotting several of the curves submitted, that a *constant* difference appeared which, it was thought, might be due to the fact that the spectrophotometers were simultaneously measuring two kinds of reflection—diffuse reflection, which is the color of the sample, and specular or front face reflection which does not necessarily indicate the color of the sample. When this constant difference was applied to the spectrophotometer curve, as a correction, the result was a striking concordance with the sphere curve. The files of the sub-committee contain a copy of the report of the sub-committee for April 10, 1925, with Mr. Little's comments and a set of curves prepared by him showing the effect of the correction mentioned on a set of spectrophotometer curves turned into the committee.

In the light of this new fact the instruments were again overhauled and, after preliminary work carried on through the summer, it was decided to learn if it were possible for even a fairly accurate and reproducible spectral reflection curve to determine the color of a paint sample with an accuracy of the order of wet matching, or which would even suffice to hold deliveries up to standard shade as closely as the average commercial requirements demand.

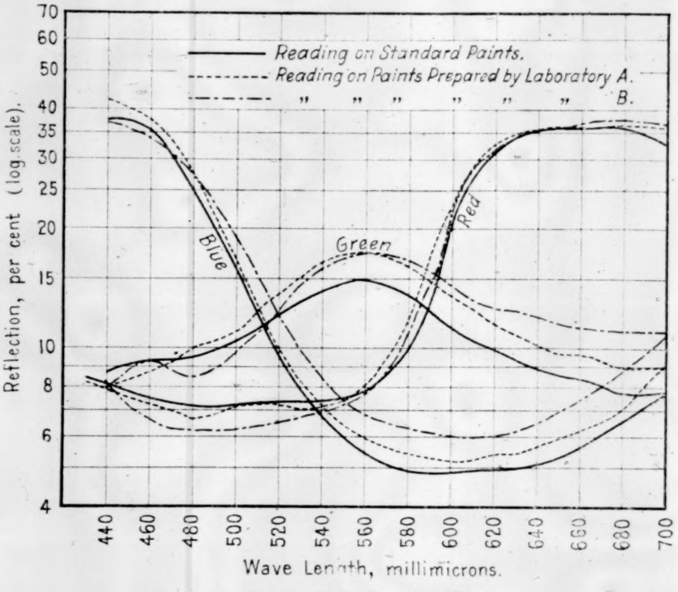

FIG. 1.—Spectral Reflection Curves.

Accordingly, three paints were prepared, a red, a green and a blue, all of medium saturation as to hue. The pigments used were selected because of the large volumes used in the paint industry, accounting for perhaps over two-thirds of all the paints sold in this country. The white pigments were white lead (basic carbonate), zinc oxide, lithopone and titanox; the red pigments were toluidin red (98.5 per cent organic) and iron oxides; the yellow pigment was French ocher; and the blue pigments were ultramarine and ferrocyanide (Chinese) blue; the vehicles were mostly raw linseed oil and turpentine, with small amounts of heat-polymerized linseed oil, and lead and manganese linoleate drier. Chrome yellows and greens were intentionally omitted because in the strong illumination of the instruments used they darken just as they do when exposed to sunlight. The details of the preparation of these paints are given in a folder in the files of the sub-committee, together with their spectral reflection curves.

In September, 1925, these paints were applied to clean metal—two coats with two or three days between for drying—and after an interval of three days the painted samples were sent to Mr. Keuffel to have the spectral reflection curves made. Specifications were then drawn indicating, in the usual manner, the type of paint desired and the materials to be used. To members of the sub-committee who were equipped with paint-making machinery, the specifications and curves were sent, together with instructions to prepare a set of paints according to the specifications, adjusting the color by changing the proportions of the pigments until a curve should be obtained as nearly as possible the same as the standard curve. Instructions were also given to keep a record of the number of trials made and the time consumed. When these paints were finished they were to be sent to Mr. Paul to be compared with the standards which had been retained in his possession. The operators had no sample of paint, nor any guide to the color or shade demanded other than the spectral reflection curves made by Mr. Keuffel. Two of the operators, Mr. Bryce and Mr. Breyer, had finished the work in time to have the results in hand early in the year. Figure 1 shows the curve on each of the three standard colors, together with six curves representing the readings on the samples prepared by Mr. Bryce and Mr. Breyer.

At the time of the meeting of Committee D-1 held at Providence in March, 1926, the report of the sub-committee gave the main facts and submitted the results from the members who had finished the work assigned. The paints handed in were painted out in a parallel manner with the original standards and were found to match in color with very satisfactory closeness, especially when it is borne in mind that the greatest number of trials in any case was four. To these two members, therefore, Mr. Bryce first, and Mr. Breyer a close second, must be accorded the distinction of being the first persons to prepare actual commercial samples of paints that match closely in color a set of standards *they had never seen*. The "test" seems to have been passed successfully.[1]

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[1] A folder in the files of the sub-committee shows the painted samples as they now are, after several months have elapsed.

It should be pointed out that wherever there was a difference in shade between the submitted paints and the standards there was an exactly corresponding difference in the curves, a fact that proved the soundness of the method even more conclusively than if the curves had been coincident throughout.

The lack of complete concordance in these curves has a further significant interest. Take the three green curves for example. The composition specification for this green calls for French Yellow Ocher, only, as the yellow element, with Chinese Blue as the blue element. Now while the good Chinese Blues in the market do not vary greatly in tone, the ochers vary very considerably, and may be roughly classified as reddish, medium, and pale or "citron." In the standard sample the best grade of citron ocher was used, a shade of ocher distinctly more greenish than regular J.F.L.S., but no hint of this was given in the specification, and the operators used the ochers they had at hand. If an experienced shade-mixer in the factory had been called upon to match the wet standard he would have soon observed that no possible proportion of reddish or medium ocher would give an exact match, and he would have turned at once to citron ocher, or tried to touch up the mix with chrome yellow—violating the specification.

A glance at these green curves shows at once that when the curve is properly adjusted in those regions of the spectrum influenced by the pigments other than ocher, the curves of the operators' paints are considerably higher than the standard in the yellowish-red region, and the configuration in this region is also different. Obviously no increase or decrease in the ocher will bring about a proper configuration in this region, nor will change in the proportions of any of the other specified pigments have any appreciable effect on the configuration in this region. Therefore, to attain the desired result a considerable amount of the yellowish-red element must be removed, and the best way to remove it is to use an ocher which does not contain so much of it in the first place, that is, a greener, or more "chromey" ocher. These curves show clearly that the ochers used by the operators were different in tone from the one used in preparing the standard sample, and, further, they show that even these two other ochers differed in tone from each other.

Coming back to the question as to whether the spectral reflection curves equal "wet matching" in accuracy, the answer is probably negative when the question is propounded in this form, for however imperfect the eye may be as an optical instrument, it is nevertheless capable, by experience, of acquiring the power to detect extremely small color differences between two samples placed side by side—differences that no optical instrument now known can really measure, and perhaps not even reveal. But in industrial work it is not fair to ask the question in that precise form, for down to 1923 not a single paint manufacturing concern, or at least none within our knowledge, had in actual operation any scientific method of checking standards; since then a bare half-dozen have installed spectrophotometers as an essential part of their laboratory equipment, and, to the extent that such instruments have been brought into use,

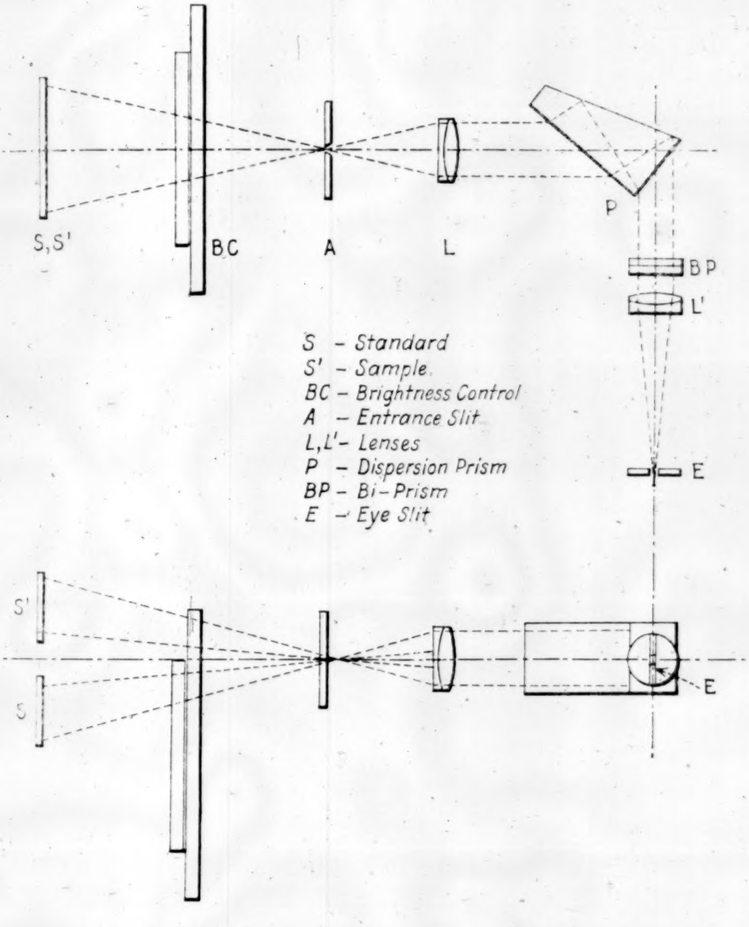
S,S'
BC
A
L
P
BP
L'
S - Standard
S' - Sample
BC - Brightness Control
A - Entrance Slit
L,L'- Lenses
P - Dispersion Prism
BP - Bi-Prism
E - Eye Slit
E
S'
S
E

FIG. 2.—Diagram of Typical Set-up Employed in Making Color Analyses.

these concerns must be excepted, otherwise the former situation still obtains.

The instability of the wet master-sample preserved in sealed containers is only surpassed by the notorious inadequacy of the ordinary color card. Fortunately, however, there are a number of pigments which may be preserved in the dry form for extended periods without serious change, and when these, or combinations of them, are made up into paints by a carefully prescribed formula, the resultant colors show a very satisfactory constancy. With such paints in key positions it is not so very difficult to hold a full line fairly steady and keep it from drifting far away from the adopted shades.

All this, however, does not impose on the spectral reflection curve the necessity of an accuracy equal to the process of wet matching, for, however accurate this process may be, and however useful in the regular operations of paint production *after* the standard color desired has been fixed, the main question of importance is whether or not the standard itself has maintained its fixity over an extended period of time. It is from this condition of uncertainty that the curve offers gratifying relief. When one considers the pronounced color changes in paints after application, whether the dried films be exposed to the sun and weather or kept in the dark, the rational mind may be pardoned for feeling no grave concern over differences that do not show on a sound spectral reflection curve.

Summing up the salient points of this report the sub-committee believes it has demonstrated certain facts of fundamental importance in writing specifications embracing the color of paints, and of considerable importance to the paint industry in general; possibly also to other industries having similar color problems. These facts are:

1. The spectral reflection curve is a sound and reasonably accurate measure of the color of paints as stimuli of color vision, and the quantities expressing the measure have the advantage of being expressed in fundamental physical units.

2. In determining this curve by means of the spectrophotometer the method of illumination must be specified to obtain concordant curves. Whatever the source of light employed the method of illumination should be definite.

3. The curve furnishes a ready means of checking up paint color standards, and of recording them in a convenient and permanent form.

4. If a standard sample has been lost, or has gone badly off color on storage, it may be reproduced by means of the curve alone, but much more easily if the production formula has also been kept.

5. If two paints yield the same curve they will match under any kind of illumination, but the converse of this proposition is not necessarily true. Paints may match in daylight and differ considerably under artificial light; such paints yield different curves.

6. The use of the spectrophotometer is limited to a certain extent by the fact that some pigments fade, or change, when exposed to the strong illumination long enough for the readings to be taken. In some cases this obstacle can be surmounted by using a large number of samples, one for each reading; but the method is clumsy and there is reason to hope that some type of adequate illumination may be devised which all useful pigments will be able to resist for at least twenty minutes.

Respectfully submitted on behalf of the sub-committee,

F. P. INGALLS,
Chairman.

M. REA PAUL,
Secretary.

REPORT OF COMMITTEE D-2
ON
PETROLEUM PRODUCTS AND LUBRICANTS

Committee D-2 on Petroleum Products and Lubricants has held three regular meetings during the past year (in June at Atlantic City, in October at Tulsa and in April at Baltimore), and also an informal meeting at Los Angeles, Calif., at the time of the annual meeting of the American Petroleum Institute, as has been the custom for several years.

Five new sub-committees have been formed during the past year, as follows:

- XXVIII on Motor Oils.
- Special Sub-Committee on Lubricating Oil Specifications, to cooperate with a committee of the Federal Specifications Board regarding plans for the government purchase of lubricating oil.
- Special Sub-Committee on S.A.E. Viscosity Numbers, to cooperate with the Lubricants Division of the Society of Automotive Engineers in developing a plan to simplify the purchase of crankcase oil of the proper viscosity, by the use of numbers.
- Special Sub-Committee to cooperate, in conjunction with Committee D-7 on Timber, with the American Wood Preservers' Association in solving problems relative to the use of petroleum products in wood preservation.
- Special Sub-Committee on Public Relations.

The sub-committee organized last year as a Special Sub-Committee on Application of Tests has since been designated Sub-Committee XXVII.

The name of Sub-Committee XI on Emulsification has been changed to Sub-Committee XI on Turbine Oils.

The voting membership of this committee now consists of 39 producer and 41 non-producer members.

NEW TENTATIVE STANDARDS

The committee is presenting for approval for publication as tentative standards, the following proposed methods of test:

1. *Method of Test for Burning Quality of Mineral Colza Oil*, submitted by Sub-Committee XIX on Illuminating Oils (J. B. Rather, chairman), and appended hereto.[1] This method is based on Method 210.41, ***Bulletin No. 323A***, U. S. Bureau of Mines, and on the principle of fixed oil consumption rather than fixed burning time.

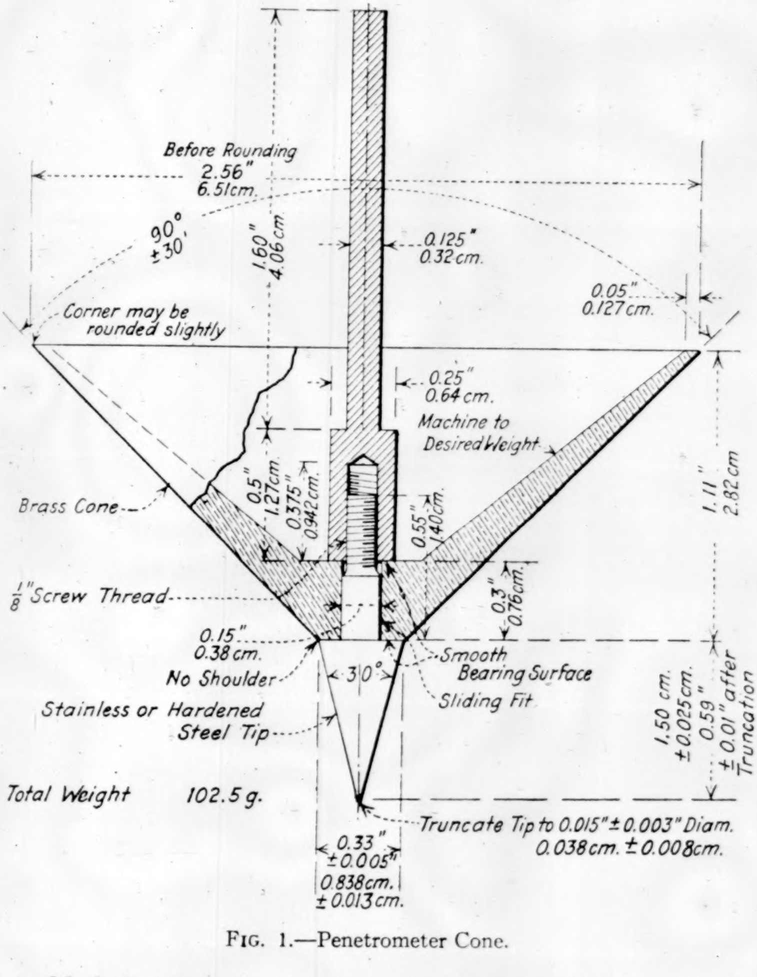
Before Rounding
2.56"
6.51cm.
90°
±30'
1.60"
4.06cm
0.125"
0.32cm.
0.05"
0.127cm.
Corner may be rounded slightly
0.25"
0.64cm.
Machine to Desired Weight
Brass Cone
0.5"
1.27cm.
0.375"
0.942cm.
0.55"
1.40cm.
1.11"
2.82cm
1/8" Screw Thread
0.3"
0.76cm.
0.15"
0.38cm.
No Shoulder
Smooth Bearing Surface
30°
Sliding Fit
Stainless or Hardened Steel Tip
1.50 cm.
±0.025cm.
0.59"
±0.01" after Truncation
Total Weight 102.5 g.
Truncate Tip to 0.015"±0.003" Diam.
0.038cm.±0.008cm.
0.33"
±0.005"
0.838cm.
±0.013cm.

FIG. 1.—Penetrometer Cone.

2. *Method of Test for the Thermal Value of Fuel Oil*, submitted by Sub-Committee XXIV on Calorific Value (F. A. Hull, chairman), and appended hereto.[2] The recommendation that this method be adopted as a tentative standard is based upon experimental work covering a period of two years, and the data that have been

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[1] See p. 844.—ED.

[2] See p. 855.—ED.

secured have been filed in the office of the Society. These data show that, notwithstanding the fact that cooperating analysts have deviated in some cases from the recommended procedure, the average deviation in results is relatively small, and it is felt that the method, when properly used, will give results that are entirely satisfactory.

RECOMMENDED REVISION OF TENTATIVE STANDARDS

The committee recommends certain changes in the following tentative methods of test, and upon approval of these revisions, that they be continued as tentative.

1. *Tentative Method of Test for Penetration of Greases (D 217–25 T)*[1].—The revisions recommended, as submitted by Sub-Committee IV on Grease, are as follows:

Figure 2.—The diagram of the grease cone should be changed in certain minor respects to agree with the accompanying Fig. 1, mainly in the interest of greater clarity. These changes for the most part were suggested by the gage section of the U. S. Bureau of Standards and transmitted by Mr. Herschel. The specific changes are as follows:

(*a*) The addition of the legend "no shoulder" with an arrow pointing to the junction between the tip and cone proper.

(*b*) The tolerance of the base of the small cone is reduced from 0.01 in. to 0.005 in. The new dimension reads 0.33 in. ±0.005 in.; 0.838 cm. ±0.013 cm.

(*c*) The dimension for the height of the tip is reduced 0.01 in. to 1.50 cm. ±0.025 cm. (0.59 in. ±0.01 in.) after truncation, in order to make the 30-deg. triangle check up properly.

(*d*) The word "truncation" in this dimension is put *below* the word "after," instead of to the right to avoid misunderstanding.

(*e*) The note with regard to the tip is changed to read as follows:

(First line) Truncate tip to 0.015 in. ±0.003 in. Diam.
(Second line) 0.038 cm. ±0.008 cm.

(*f*) The hole in the center rod is shown with a tapered bottom instead of a flat bottom which implies counter boring.

2. *Tentative Method of Analysis of Grease (D 128–24 T).*[2]—A slight revision is recommended, as submitted by Sub-Committee IV on Grease, as follows:

Section 23.—Change the specified concentration of alcohol from 70 per cent to 50 per cent, in order to eliminate some difficulties in determining the alkalinity of lime greases.

3. *Tentative Method of Test for Sulfur in Naphthas and Illuminating Oils (D 90 – 24 T).*[3]—The following revision, as submitted by Sub-

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 701 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 352.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 874 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 343.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 894 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 387.

Committee VII on Sulfur Determination and Differentiation, is recommended, consisting of the addition of a footnote reference to the present paragraph on scope, the footnote to read as follows:

> "If high volatility motor fuels are tested by this method, and especially if they contain benzol, it is very important that the suction be regulated so that the height of the flame is not more than $\frac{1}{4}$ in."

4. *Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (D86-25T).*[1]—Recommended revisions as submitted by Sub-Committee VIII on Distillation (E. W. Dean, chairman) are as follows:

Section 8. (d).—Add the following sentence:

> "The thermometer shall be approximately at room temperature when placed in the flask."

Section 9.—Insert the following between the first and second sentences of the first paragraph:

> "The distillation thermometer shall be read 2 minutes after heat is applied and the indication recorded as the 'correction temperature.' This figure is of significance only in cases when there is a question as to the accuracy[a] of the initial boiling point, as subsequently determined."

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[a] The initial boiling point is one of the observations which it is customary to report as indicative of the quality of gasoline. It is a point which is very difficult to check, especially when duplicate tests are made at different room temperatures, and it has not been found practical to devise an accurate method of correcting for this unavoidable variation in operating conditions. The practical significance of initial boiling point is not regarded as sufficient to warrant requiring that tests be conducted under regulated conditions of room temperature. The following directions are included as an expedient intended to obviate some of the difficulties that develop on account of the practice of including initial boiling point limits in specifications for the purchase and sale of gasoline:

If the "correction temperature" is below 70° F. (21° C.) or above 80° F. (27° C.), the observed initial boiling point, if it is below 150° F. (66° C.), may be considered incorrect by an amount not less than one third the difference between the "correction temperature" and 75° F. (24° C.). In case there is a dispute between buyer and seller, the observed initial boiling point figures obtained by all parties shall be revised according to the following formula:

$$\text{Revised initial boiling point} = \left\{\begin{matrix}\text{observed initial}\\ \text{boiling point}\end{matrix}\right\} - \frac{\text{Correction Temperature (deg. Fahr.)} - 75}{3}$$

If all of the revised figures fall within the specification limit the gasoline in question shall be considered as passing; otherwise arrangements shall if possible be made to conduct a distillation test with the room temperature maintained between the limits of 70 and 80° F. (21 and 27° C.) inclusive.

Section 9.—At the end of the first paragraph add the following:

> "If preferred, the reading of the distillation thermometer may be observed and recorded when the level of the distillate reaches each 10-cc. mark on the graduate. In case a product is being tested to ascertain whether or not it conforms with a given specification, all necessary observations shall be made and recorded, whether or not they are included in the series ordinarily employed by the laboratory making the test."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 685 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 325.

Section 10.—Add to this section the following:

"Duplicate readings of the volume of distillate collected in the cylinder when each of the prescribed temperature points is reached should not differ from each other by more than 2 cc. In case observations are made on the basis of prescribed percentage points, the differences in temperature readings should not exceed the amounts equivalent to 2 cc. of distillate at each point in question."

5. *Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 – 25 T).*[1]—The revision recommended, as submitted by Sub-Committee XIII on Neutralization Number and Saponification, is that a footnote reference be added to Method C (Section 6), the footnote to read as follows:

"When the oil is acid, the acidity shall not be reported as sulfuric or hydrochloric acid, unless the presence of these acids shall have been confirmed by tests."

6. *Tentative Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 – 25 T).*[2]—A slight modification of this method, as submitted by Sub-Committee XIX on Illuminating Oils (J. B. Rather, chairman) is recommended as follows:

Section 5.—In the first line of this section, omit the word "Macbeth" and add the following as a footnote to the words "55-D Chimney":

"This term, '55-D Chimney,' is fully descriptive with glass manufacturing companies as the long-time burner chimney covered by these specifications."

ADVANCEMENT OF TENTATIVE STANDARD TO STANDARD

The committee recommends for submission to letter ballot of the Society, for adoption as standard, the Tentative Method of Test for Viscosity of Petroleum Products and Lubricants (D 88 – 25 T)[3] with a slight rearrangement of the material in Section 4 on Procedure, and with the addition of a footnote regarding the pipette for draining the overflow cup.

Section 4.—Change to read as follows:

"In tests at 100 and 130° F. (37.8 and 54.4° C.) the bath temperature throughout the test shall not vary more than ± 0.1° F. (0.06°C.) from the predetermined temperature which will maintain thermal equilibrium as long as the oil is well stirred with the thermometer. In tests at 210° F. (98.9° C.) a variation of ± 0.2° F. (0.11° C.) is permitted.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 722 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 406.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 718 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 383.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 707 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 358.

"Any construction of bath may be employed provided the bath temperature necessary to maintain thermal equilibrium (while the oil in the oil tube is well stirred by the oil tube thermometer) is not in excess of 100.25, 122.35, 130.50 and 212.00° F. (37.9, 50.2, 54.7 and 100.00° C.), respectively, for the standard temperatures previously mentioned. The level of the bath liquid shall not be lower than 0.5 cm. above the overflow rim of the oil tube. In tests at 210° F. (98.9° C.) the water bath shall be vigorously stirred, and may be heated by the direct injection of steam near the bottom of the bath. A bath of other suitable liquid may be used provided it is properly heated and stirred.[a] The heating and stirring of the bath may be accomplished by any suitable means, provided the source of heat is not less than the following distances from any part of the oil tube: 2 in. (5 cm.) with an external heater, 1¼ in. (3 cm.) with an immersion heater. Viscosity determinations shall be made in a room free from draughts and from rapid changes in temperature. The room temperature shall be between 68 and 86° F. (20 and 30° C.).[b]

"All oil introduced into the oil tube, either for cleaning or for test, shall first be passed through the strainer.

"To make the test, heat the oil to the necessary temperature and clean out the oil tube. Pour some of the oil to be tested through the cleaned tube. Insert the cork stopper into the lower end of the air chamber at the bottom of the oil tube, sufficiently to prevent the escape of air, but not to touch the small outlet tube.

"Heat the oil to be tested, outside the viscosimeter, to slightly but not more than 3° F. (1.7° C.) above the temperature at which the viscosity is to be determined, and pour it into the oil tube until it ceases to overflow into the overflow cup. By means of the oil tube thermometer, keep the oil in the oil tube well stirred, and also stir well the liquid in the bath. It is extremely important that the temperature of the bath be maintained constant during the entire time consumed in making the test. After the temperature of the bath and of the oil in the oil tube have been constant for one minute at the desired temperatures, withdraw the oil tube thermometer, quickly remove the surplus oil from the overflow cup by means of a pipette[c] so that the level of the oil in the overflow cup is below the level of the oil in the oil tube proper; place the 60-cc. flask, Fig. 2, in position so that the stream of oil from the outlet tube will strike the neck of the flask so as to avoid foam. Snap the cork from its position, and at the same instant start the stop-watch. Stir the liquid in the bath during the run and carefully maintain it at the previously determined proper temperature. Stop the watch when the bottom of the meniscus of the oil reaches the mark on the neck of the receiving flask.

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[a] For example, the bath liquid may be water, to which glycerin or salt has been added. In ordinary routine testing it is frequently desirable to employ oil as a bath medium. This is allowable provided the temperature of the oil bath is adjusted so that the necessary condition of thermal equilibrium is maintained. It is usually necessary to maintain the oil bath at slightly higher temperatures than are necessary when water is the bath medium. Oil bath temperatures will need to be from 0.1 to 0.2° F. (0.06 to 0.11° C.) higher for tests at 100° F. (37.8° C.) and 1.5 to 2.0° F. (0.85 to 1.11° C.) higher for tests at 210° F. (98.9° C.) than the corresponding water bath temperatures.

[b] These limits are necessary for extreme accuracy in standardization and referee tests, but for routine purposes the use of higher temperatures up to 100° F. (37.8° C.) will not ordinarily cause an error of more than 1 per cent.

[c] It is recommended that the tip of the pipette should be about 2 mm. inside, and about 3 mm. outside diameter, and great care should be exercised to avoid touching the overflow rim while draining the overflow cup.

"The time in seconds for the delivery of 60 cc. of oil is the Saybolt Universal (or Saybolt Furol) viscosity of the oil at the temperature at which the test is made.

"With proper attention to details of methods of procedure, duplicate results should not differ from each other by more than 1 per cent."

Appended hereto are reports of the following sub-committees:

- Sub-Committee I on Petrolatum;
- Sub-Committee IV on Grease;
- Sub-Committee VII on Sulfur Determination and Differentiation;
- Sub-Committee XI on Turbine Oils;
- Sub-Committee XIII on Neutralization Number and Saponification;
- Sub-Committee XXV on Crankcase Dilution;
- Sub-Committee XXVI on Petroleum Wood Preservatives;
- Sub-Committee XXVII on Application of Tests.

The recommendations appearing in this report have been submitted to letter ballot of the committee, which consists of 81 members: 52 ballots have been returned, and 29 members have refrained from voting. The result of the letter ballot is as follows:

Item	Affirmative	Negative	Not Voting
I. ADVANCEMENT OF TENTATIVE STANDARD TO STANDARD			
Method of Test for Viscosity of Petroleum Products and Lubricants (D 88 - 25 T)	50	0	31
II. PROPOSED NEW TENTATIVE STANDARDS			
Method of Test for Burning Quality of Mineral Colza Oil	44	0	37
Method of Test for Determination of the Thermal Value of Fuel Oil	48	0	33
III. PROPOSED REVISION OF EXISTING TENTATIVE STANDARDS			
Method of Test for Penetration of Greases (D 217 - 25 T)	47	0	34
Method of Test for Analysis of Grease (D 128 - 24 T)	47	0	34
Method of Test for Sulfur in Naphthas and Illuminating Oils (D 90 - 24 T)	45	0	36
Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (D 86 - 25 T)	46	1	34
Method of Test for Neutralization Number of Petroleum Products and Lubricants (D 188 - 25 T)	46	0	35
Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (D 219 - 25 T)	44	0	37

This report has been submitted to letter ballot of the committee, which consists of 81 members, of whom 51 have voted affirmatively, none negatively, and 30 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. P. VAN GUNDY,
Chairman.

R. P. ANDERSON,
Secretary.

EDITORIAL NOTE

The Tentative Methods of Test for Viscosity of Petroleum Products and Lubricants were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed Tentative Method of Test for Burning Quality of Mineral Colza Oil; and for the Thermal Value of Fuel Oil were accepted for publication as tentative and appear on pages 844 and 855, respectively.

The proposed revisions of the Tentative Method of Test for Penetration of Greases; for Analysis of Grease; for Sulfur in Naphthas and Illuminating Oils; for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products; for Neutralization Number of Petroleum Products and Lubricants; and for Burning Quality of Long-Time Burning Oil for Railway Use were accepted for publication as tentative and appear on pages 816, 843 and 848 to 854.

REPORT OF SUB-COMMITTEE I ON PETROLATUM

This sub-committee, after due consideration of the trade situation with respect to petrolatum, feels that a careful study should be made of the relationship, if any, existing between the so-called melting point and the so-called consistency. Accordingly, during the coming year, members of the sub-committee will examine various grades of petrolatum, using the A.S.T.M. Standard Method of Test for Melting Point of Paraffin Wax (D 87 – 22), the so-called "plate" method, the Tentative Method of Test for Penetration of Greases (D 217 – 25 T) (which may have to be modified for petrolatums), the McMichael viscosimeter, and several other devices now in process of development.

It is hoped that the data thus secured may be of considerable educational value to the general public as well as to the members of the Society.

Respectfully submitted on behalf of the sub-committee,

F. A. Hull,
Chairman.

REPORT OF SUB-COMMITTEE IV ON GREASE

No new work has been carried on by this sub-committee during the past year. The method of testing the penetration of grease has been used by a number of laboratories, apparently with entire success, as no criticisms have been made in response to various inquiries.

Mr. Herschel carried out comparative tests with a standard cone and two other cones just at the tolerance limits on either side of the standard dimensions, and was unable to detect any consistent difference in results.

A few minor changes have been made in the figure showing the grease cone, and one change in the method of analysis of grease, both of which are reported elsewhere.[1]

Respectfully submitted on behalf of the sub-committee,

Robert E. Wilson,
Chairman.

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[1] See p. 360.—Ed.

REPORT OF SUB-COMMITTEE VII ON SULFUR DETERMINATION AND DIFFERENTIATION

The work on determination of sulfur in motor fuels containing carbon bisulfide has been continued.

Samples of motor fuels containing 35 per cent of benzol were prepared, bottled and labeled on different days, to avoid possibilities of misbranding. Two of the samples received an addition of carbon disulfide. The samples marked No. 4 and No. 5 were distributed for examination by means of the Tentative Method of Test for Sulfur in Naphthas and Illuminating Oils (D 90 – 24 T) and the Tentative Method of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil (D 129 – 22 T) (both slightly modified), while samples marked No. 6 and No. 7 were distributed for examination by Method D 90 – 24 T, and by the Kennedy lamp. Mr. Kennedy distributed the necessary lamps and directions for using them, while the following directions were distributed with samples Nos. 4 and 5:

1. The samples should be tested as soon as possible. By keeping the samples in a cool place for a short time before opening the bottles and while the tests are made, the possibility of loss of volatile components will be minimized.

2. In the case of tests by Method D 90 – 24 T, the top of the wick should be kept level with the top of the wick tube, regulating the suction so as to produce a flame approximately ¼ in. high.

(To insure uniformity in the quality of the wicks used in the various laboratories, a sufficient quantity of wicking was enclosed with the samples.)

3. The following modification in the details of Method D 129 – 22 T is suggested:

A portion of the material to be tested should be placed in a weighing bottle (a 30-cc. Erlenmeyer flask with a tight-fitting cork carrying a small pipette provided with a rubber bulb, similar to a medicine dropper). The whole should be weighed. The lid of the bomb, with oil cup in position and ignition wire attached, should be placed on a suitable stand. A small fluffy tuft of cotton (about 3 to 5 mg.) should be placed in the cup on top of the ignition wire to start the combustion. A suitable quantity of material (about 1 g.) should then be transferred to the cup from the weighing bottle, after which the lid should be quickly placed in position on the bomb and screwed tight. The bomb should then be filled with oxygen under 35 to 40 atmospheres pressure. The weighing bottle and contents shall then be weighed, the difference being the amount of material used.

In the bomb there should have been previously introduced 15 to 20 cc. of a 1-per-cent solution of ammonium carbonate. The latter is used with the intention of retaining all of the acid products of combustion of the sulfur, part of which is alleged to escape when water is used.

The bomb shall be placed in a bucket of cold water and the material ignited, after which the bomb should be allowed to remain in the water for ten minutes. The procedure after this is similar to that of D 129 – 22 T.

TABLE I.—RESULTS OF COMPARATIVE TESTS EMPLOYING VARIOUS METHODS IN DETERMINING SULFUR IN FUEL OIL.

SAMPLE NO. 4

Carbon bisulfide.................... Absent
Sulfur content, calculated.................... 0.163 per cent

	Sulfur, per cent								
	Method D 90 – 24 T			Bomb Method			Kennedy Method		
	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
Laboratory 1 A..	0.166	0.154	0.157	0.160	0.150	0.157	0.160	0.156	0.158
Laboratory 1 B..	0.161	0.157	0.159	0.159	0.155	0.157			
Laboratory 2 A..	.....	.....	0.157	.....	.....	0.210	.....	.....	.....
Laboratory 2 B..	.....	.....	0.160	.....	.....	0.200	.....	.....	.....
Laboratory 3......	.....	.....	0.160	.....	.....	0.135	.....	.....	.....
Laboratory 4......	0.152	0.144	0.148	0.238	0.192	0.211	.....	.....	.....
Laboratory 5......	0.166	0.166	0.166	0.188	0.185	0.186	.....	.....	.....
SAMPLE NO. 5									
Carbon bisulfide.......... Present									
Sulfur content, calculated.......... 0.20 per cent									
Laboratory 1 A..	0.212	0.210	0.211	0.210	0.200	0.205	0.180	0.180	0.180
Laboratory 1 B..	0.218	0.204	0.211	0.211	0.207	0.209			
Laboratory 2 A..	.....	.....	0.164	.....	.....	0.220	.....	.....	.....
Laboratory 2 B..	0.088	0.042	0.065	0.210	0.200	0.205	.....	.....	.....
Laboratory 3......	.....	.....	0.150	.....	.....	0.191	.....	.....	.....
Laboratory 4......	0.173	0.166	0.169	0.202	0.187	0.185	.....	.....	.....
Laboratory 5......	0.168	0.165	0.167	0.203	0.194	0.198	.....	.....	.....
SAMPLE NO. 6									
Carbon bisulfide.......... Absent									
Sulfur content, calculated.......... 0.089 per cent									
Laboratory 1......	0.084	0.084	0.084	.....	.....	.....	0.082	0.080	0.081
Laboratory 3......	0.092	0.088	0.090	.....	.....	.....	0.087	0.080	0.084
Laboratory 4......	0.093	0.082	0.088	.....	.....	.....	0.087	0.075	0.083
Laboratory 5......	0.077	0.075	0.076	.....	.....	.....	0.082	0.082	0.082
SAMPLE NO. 7									
Carbon bisulfide.......... Present									
Sulfur content, calculated.......... 0.088 per cent									
Laboratory 1......	0.92	0.087	0.090	.....	.....	.....	0.084	0.080	0.082
Laboratory 3......	0.100	0.094	0.097	.....	.....	.....	0.093	0.089	0.091
Laboratory 4......	0.089	0.081	0.085	.....	.....	.....	0.092	0.087	0.088
Laboratory 5......	0.065	0.063	0.064	.....	.....	.....	0.078	0.078	0.078

The results obtained by the members of the sub-committee are presented in the accompanying Table I.

The sub-committee recommends that further work on determination of sulfur in gasolines or blended motor fuels by the bomb method be discontinued.

The sub-committee recommends that the comparison of Method D 90 - 24 T and the Kennedy Vapor Lamp Method be continued, using in this work samples of motor fuels free from carbon bisulfide as well as samples containing more carbon bisulfide than sample No. 7.

Respectfully submitted on behalf of the sub-committee,

ERNST JOHANSEN,
Chairman.

REPORT OF SUB-COMMITTEE XI ON TURBINE OILS

The name of this sub-committee was changed, at the April meeting of Committee D-2 in Baltimore, from that of "Emulsification" to that of "Turbine Oil."

This committee for several years did concentrated work on studying the A.S.T.M. Emulsion Test formerly known as the R. E. Test and the Herschel Demusibility Test. Every effort was made to thoroughly try out both methods and make any corrections in both that would tend to give better results. Improvements were suggested in running these tests and a large amount of time and effort was devoted to the work. The result has been that the A.S.T.M. Steam Emulsion Test has been accepted as a tentative standard entitled Method of Test for Steam Emulsion of Lubricating Oils (D 157 – 23 T) as published in the report of Committee D-2 for 1923.

A progress report was published in the report of Committee D-2 for 1924, in which it was recommended that in reporting the results of the A.S.T.M. Steam Emulsion Test the readings be reported in seconds rather than minutes or half minutes, in order to obtain closer readings.

The work performed by the committee during 1925 was not published in the report of Committee D-2 for 1925 as preprinted, but is published in the report as printed in the Proceedings of the Society.[1] A summary is given in Table I.

Several years ago, some cooperative work was started by this committee with the larger users of turbine oils, and it was found that in so doing, the committee was too large to get quick and definite results. Therefore, a sub-sub-committee was formed to cooperate on this special work, and to carry on a series of experiments with the Funk Sludge Accelerator in conjunction with the Steam Emulsion and Herschel Demulsibility Tests. Mr. N. E. Funk of the Philadelphia Electric Co. sent out seven samples of turbine oils (see Table II) to representatives of oil companies and electric companies who possessed this sludge accelerator. In addition to these tests, small samples were sent out to a few members of the committee who were in the vicinity of New York, for Steam Emulsion and Herschel Demulsibility Tests. Representatives of many of the principal electric companies have been cooperating with the committee in all of its work.

The results of the work on the A.S.T.M. Steam Emulsion and the Herschel Demulsibility Tests clearly indicate that more concordant

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 272 (1925).

TABLE I.—SUMMARY OF AVERAGE RESULTS OF COOPERATIVE WORK ON A.S.T.M. EMULSION AND HERSCHEL DEMULSIBILITY TESTS, PERFORMED DURING 1925.[1]

Laboratory	Date of Test	A.S.T.M. Emulsion Test, R. E., in seconds.			
		Oil No. 24-1		Oil No. 24-2	
		Sample Measured at Room Temp	Sample Measured at 200° F	Sample Measured at Room Temp.	Sample Measured at 200° F.
No. 1	Oct. 15, 1924	62	61	69	69
No. 2	Oct. 14, 1924	53	44	58	66
No. 4	Oct. 15, 1924	45	42	72	70
No. 5	Oct. 20, 1924	64	75	71	78
No. 6	Oct. 20, 1924	83	60	77	65
No. 7	Oct. 22, 1924	55	62	62	65
No. 8	Oct. 24, 1924	51	51.5	57.5	55.5
No. 9	Oct. 27, 1924	60	...	60	...
No. 10	Oct. 31, 1924	54	55.5	54	55
No. 11	Oct. 30, 1924	60	52	63	66
No. 12	Nov. 11, 1924	71	57	88	66
No. 13	Nov. 14, 1924	55	59	67	69
No. 14	Nov. 22, 1924	53	54	57	57
No. 15	Oct. 24, 1924	51	63	58	68
No. 16	Nov. 28, 1924	35	37	4	3
No. 17	Dec. 31, 1924	57	56	63	65
No. 3	Dec. 1, 1924 (Corrected Results)	62	68	67	78
No. 18	Jan. 21, 1925	53	...	63	...
No. 19	Dec., 10, 1924	50	40	55	60

Labora-tory	Date of Test	Herschel Demulsibility Values				Time for 27 cc. of Oil to Separate, min.			
		Oil No. 24-1		Oil No. 24-2		Oil No. 24-1		Oil No. 24-2	
		At 100° F.	At 130° F.	At 100° F.	At 130° F	At 100° F.	At 130° F.	At 100° F.	At 130° F
No. 1	Oct. 15, 1924	790	1540	520	1540	2.7	2.0	4.0	2.0
No. 2	Oct. 14, 1924	413	1540	398	750	5.0	2.0	5.0	3.0
No. 5	Oct. 17, 1924	1500	1620	533	1620	2.0	1.0	4.5	1.0
No. 6	Oct. 20, 1924	1620	1620	1620	1620	1.0	1.0	1.0	1.0
No. 7	Oct. 24, 1924	690	1560	585	1560	3.0	2.0	4.0	2.0
No. 8	Oct. 24, 1924	1560	1620	1500	1620	2.0	1.0	2.0	1.0
No. 9	Oct. 27, 1924	520	1520	520	1530	3.7	2.0	3.7	2.0
No. 10	Oct. 31, 1924	540	1620	540	1620	4.0	1.0	4.0	1.0
No. 11	Nov. 7, 1924	720	1620	405	1560	3.0	1.0	4.0	2.0
No. 12	Nov. 13, 1924	930	1620	1050	1620	4.0	1.0	3.5	1.0
No. 13	Nov. 14, 1924	570	750	340	610	3.7	3.0	5.7	3.3
No. 16	Nov. 28, 1924	507	800	240	1140	3.4	2.1	6.7	1.7
No. 17	Dec. 2, 1924	502	1460	500	1265	3.5	1.3	4.0	2.0
No. 18	Jan. 21, 1925	780	1560	570	1200	...	...	...	...
No. 3[a]	Dec. 1, 1924	560	1230	338	630	3.0	2.5	5.5	3.5
No. 19	Dec. 10, 1924	600	1560	780	1290	3.0	2.0	3.0	2.0

[a] Corrected Results

TABLE II.—PHYSICAL TESTS OF OIL SAMPLES IN COLLABORATIVE TESTS.

	Gravity	Flash Point, deg. Fahr.	Fire Point, deg. Fahr.	Viscosity at 100° F.	Color, Lovibond $\frac{1}{2}$ in.	Pour Point, deg. Fahr.	Neutralization Number	Ash, per cent	Sulfur, per cent
Sample 25-1	19.4	305	370	138	4.5	−0	0.013	none	0.22
Sample 25-2	18.2	335	390	270	4.0	−0	0.016	0.03	0.29
Sample 25-3	17.5	345	395	352	4	−0	0.010	0.007	0.24
Sample 25-4	18.9	330	380	161	12.0	−0	0.023	0.001	0.31
Sample 25-5	17.9	340	395	287	11.0	−0	0	0.001	0.30
Sample 25-6	17.5	350	415	401	13.0	−0	0.022	0.0005	0.33
Sample 25-7	27.7	380	435	145	3.0	35	0	0	0.20

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[1] Reprinted from *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, pp. 276–277 (1925).

TABLE III.—COMPARISON OF CONCORDANCE OF RESULTS FROM DIFFERENT LABORATORIES ON THE STEAM EMULSION AND HERSCHEL DEMULSIBILITY TESTS.

Laboratory	Sample 25–1						Sample 25–2					
	A.S.T.M. - R.E.			Herschel Test			A.S.T.M. - R.E.			Herschel Test		
	Value, seconds	Deviation, seconds	Deviation, per cent	Value, cc. per hour	Deviation, cc. per hour	Deviation, per cent	Value, seconds	Deviation, seconds	Deviation, per cent	Value, cc. per hour	Deviation, cc. per hour	Deviation, per cent
A	56.0	−16.6	−23.0	840	+182	+27.7	146.0	+42.0	+40.4	930	−23	−2.4
B	75.5	+2.9	+4.0	825	+167	+25.5	97.5	−6.5	−6.4	810	−143	−15.0
C	90.0	+17.4	+24.0	780	+122	+18.6	60.0	−44.0	−42.1	1020	+67	+7.2
D	75.7	+3.1	+4.3	480	−178	−27.0	122.0	+18.0	+17.3	398	−555	−58.2
E	55.5	−17.1	−23.5	490	−168	−25.6	76.0	−28.0	−27.0	1290	+337	+35.3
F	78.4	+5.8	+8.0	678	+20	+3.0	115.0	+11.0	+10.6	1404	+451	+47.4
G	77.6	+5.0	+6.9	255	−403	−61.0	116.0	+12.0	+11.5	417	−536	−56.0
H	60.0	−12.6	−17.4	810	+152	+23.0	90.0	−14.0	−13.5	1140	+187	+19.6
I	71.0	−1.6	−2.2	810	+152	+23.0	110.0	+6.0	+5.8	1410	+457	+48.0
J	64.5	−8.1	−11.1	810	+152	+23.0	86.0	−18.0	−17.3	1320	+367	+38.5
K	94.0	+21.4	+29.5	462	−196	−30.0	127.0	+23.0	+22.1	349	−604	−63.4
Av.	72.6	±10.1	±13.9	658	±172	±26.2	104.0	±20.2	±19.4	953	±339	±35.5

Laboratory	Sample 25–3						Sample 25–4					
	A.S.T.M. - R.E.			Herschel Test			A.S.T.M. - R.E			Herschel Test		
	Value, seconds	Deviation, seconds	Deviation, per cent	Value, cc. per hour	Deviation, cc. per hour	Deviation, per cent	Value, seconds	Deviation, seconds	Deviation, per cent	Value, cc. per hour	Deviation, cc. per hour	Deviation, per cent
A	154	+27	+21.2	1260	+279	+31.0	90.0	−14.0	−13.5	1200	+642	+115.0
B	114	−13	−10.2	1200	+239	+24.9	111.0	+7.0	+6.7	1200	+642	+115.0
C	180	+53	+41.7	300	−661	−69.0	150.0	+46.0	+44.1	278	−280	−50.2
D	142	+15	+11.8	350	−611	−63.8	98.0	−6.0	−5.8	338	−220	−39.5
E	90	−37	−29.2	1200	+239	+24.9	69.5	−34.5	−33.2	360	−198	−35.5
F	130	+3	+2.4	1176	+215	+22.4	98.8	−5.2	−5.0	642	+84	+15.0
G	125	−2	−1.6	345	−616	−64.0	102.0	−2.0	−1.9	600	+42	+7.5
H	91	−36	−28.4	1140	+179	+18.6	103.0	−1.0	−1.0	350	−208	−37.2
I	122	−5	−4.0	1440	+479	+49.7	102.0	−2.0	−1.9	457	−101	−18.1
J	111	−16	−12.6	1200	+239	+24.9	102.0	−2.0	−1.9	430	−128	−23.0
K	136	+9	+7.1	....	.....	......	120.0	+16.0	+15.4	282	−276	−49.5
Av.	127	±19.6	±15.4	961	±378	±39.3	104.0	±12.3	±11.8	558	±256	±46.0

Laboratory	Sample 25–5						Sample 25–6					
	A.S.T.M. - R.E.			Herschel Test			A.S.T.M. - R.E.			Herschel Test		
	Value, seconds	Deviation, seconds	Deviation, per cent	Value, cc. per hour	Deviation, cc. per hour	Deviation, per cent	Value, seconds	Deviation, seconds	Deviation, per cent	Value, cc. per hour	Deviation, cc. per hour	Deviation, per cent
A	120.0	−12.0	−9.1	1020	+467	+84.5	150	−15.0	−9.1	660	+376	+133.0
B	125.0	−7.0	−5.3	1200	+647	+117.0	179	+14.0	+8.5	143	−141	−50.0
C	180.0	+48.0	+36.4	360	−193	−35.0	150	−15.0	−9.1	240	−44	−15.5
D	141.0	+9.0	+6.8	214	−339	−61.2	179	+14.0	+8.5	143	−141	−50.0
E	92.5	−39.5	−30.0	315	−238	−43.0	124	−41.0	−24.8	205	−79	−27.8
F	130.0	−2.0	−1.5	1020	+467	+84.5	175	+10.0	+6.1	912	+628	+221.0
G	108.0	−24.0	−18.2	600	+47	+8.5	169	+4.0	+2.4	120	−164	−58.0
H	151.0	+19.0	+14.4	322	−231	−41.9	178	+13.0	+7.9	188	−96	−33.9
I	133.0	+1.0	+0.8	437	−116	−21.0	162	−3.0	−1.8	206	−78	−27.5
J	133.0	+1.0	+0.8	383	−170	−30.7	170	+5.0	+3.0	184	−100	−35.2
K	143.0	+11.0	+8.4	210	−343	−62.0	183	+18.0	+10.9	125	−159	−56.0
Av.	132.0	±15.8	±12.0	553	±296	±53.5	165	±13.8	±8.4	284	±182	±64.0

TABLE III.—COMPARISON OF CONCORDANCE OF RESULTS FROM DIFFERENT LABORATORIES ON THE STEAM EMULSION AND HERSCHEL DEMULSIBILITY TESTS.

(*Continued.*)

Laboratory	Sample 25–7						General Average of All Seven Samples	
	A.S.T.M. - R.E.			Herschel Test			A.S.T.M. - R.E.	Herschel Test
	Value, seconds	Deviation, seconds	Deviation, per cent	Value, cc. per hour	Deviation, cc. per hour	Deviation, per cent	Deviation, per cent	Deviation, per cent
A	33.0	−6.3	−16.0	1620	+249	+18.2	±18.9	±58.8
B	46.0	+6.7	+17.1	1620	+249	+18.2	±8.3	±52.2
C	60.0	+20.7	+52.7	1080	−291	−21.3	±35.7	±30.9
D	22.2	−17.1	−43.6	1660	+289	+21.0	±14.0	±45.8
E	....	....	....	....	....	....	±23.9	±27.4
F	27.2	−12.1	−30.8	762	−609	−44.3	±9.2	±62.5
G	63.0	+23.7	+60.3	683	−688	−50.0	±14.7	±43.6
H	42.7	+3.4	+8.7	1420	+49	+3.6	±13.0	±25.4
I	21.0	−18.3	−46.5	1620	+249	+18.2	±9.0	±29.4
J	42.0	+2.7	+6.9	1620	+249	+18.2	±7.7	±27.6
K	36.3	−3.0	−7.6	1620	+249	+18.2	±14.4	±46.5
Average	39.3	±11.4	±29.0	1371	±317	±23.2	±15.4 ±15.7	±41.0 ±41.1

results are obtained with the Steam Emulsion Test than with the Herschel Demulsibility Test. This bears out the results of the committee's work last year but in a more conclusive way. Table III shows a comparison of the concordance of results from different laboratories on these two methods of test.

It is to be noted that there is quite a variation between the different laboratories in both methods of tests, but it is clearly shown that it is much less with the Steam Emulsion Test than with the Herschel Demulsibility Test. The average for eleven laboratories on the seven samples shows about 15 per cent departure from the mean for the Steam Emulsion Test and over 40 per cent for the Herschel Demulsibility Test. Similar results were obtained by the committee in its work last year, even though the Steam Emulsion values were reported at that time only to the nearest half minutes.

Table IV shows the variation of individual test values in the same laboratory. The results from three different laboratories representing the largest number of individual tests are tabulated. It is to be noted from these results that within a single laboratory the percentage departure from the average of that laboratory is fairly moderate, but that without exception the percentage deviations are smaller for the Steam Emulsion Test than for the Herschel Demulsibility Test. Therefore, it is thought that from the results obtained in this series of tests it has been definitely proved that more concordant results can be obtained by the Steam Emulsion Test than

TABLE IV.—VARIATION OF INDIVIDUAL TEST VALUES IN THE SAME LABORATORY IN COMPARATIVE TESTS OF RESISTANCE TO EMULSIFICATION AND HERSCHEL DEMULSIBILITY.

Laboratory	Sample 25-1				Sample 25-2				Sample 25-3				Sample 25-4			
	A.S.T.M. Steam Emulsion		Herschel Demulsibility, 130° F.		A.S.T.M. Steam Emulsion		Herschel Demulsibility, 130° F.		A.S.T.M. Steam Emulsion		Herschel Demulsibility, 130° F.		A.S.T.M. Steam Emulsion		Herschel Demulsibility, 130° F.	
	Value, seconds	Deviation, seconds	Value, cc. per hour	Deviation, cc. per hour	Value, seconds	Deviation, seconds	Value, cc. per hour	Deviation, cc. per hour	Value, seconds	Deviation, seconds	Value, cc. per hour	Deviation, cc. per hour	Value, seconds	Deviation, seconds	Value, cc. per hour	Deviation, cc. per hour
D	...	...	...	..	...	..	...	..	...	..	...	..	...	..	...	..
	67	8.7	460	20	121	1	450	52	145	3	300	50	...	..	...	..
	82	6.7	500	20	127	5	345	53	150	8	375	25	...	..	...	..
	78	2.3	480	0	118	4	400	2	131	11	375	25	100	2	330	8
	..	...	...	..	...	..	...	..	145	3	...	..	96	2	345	7
	..	...	...	..	...	..	...	..	140	2	...	..	...	..	...	..
Average	75.7		480		122		398		142		350		98		338	
Deviation in Laboratory		±7.79 per cent		±2.77 per cent		±2.73 per cent		±8.96 per cent		±3.80 per cent		±9.51 per cent		±2.04 per cent		±2.22 per cent
F	..	...	...	..	...	..	....	..	132	2	1200	24	...	....	...	...
	82	3.6	600	78	120	5	1500	96	126	4	1080	96	110	11.2	750	108
	75	3.4	660	18	112	3	1320	84	136	6	1200	24	105	6.2	420	222
	78	0.4	630	48	116	1	1500	96	129	1	1140	36	92	6.8	840	198
	80	1.6	750	72	115	0	1380	24	126	4	1260	84	97	1.8	780	138
	77	1.4	750	72	112	3	1320	84	130	0	....	..	90	8.8	420	222
Average	78.4		678		115		1404		130		1176		98.8		642	
Deviation in Laboratory		±2.78 per cent		±8.49 per cent		±2.09 per cent		±5.47 per cent		±2.54 per cent		±4.49 per cent		±7.04 per cent		±27.66 per cent
G	76	1.6	252	3	117	1	400	17	123	2	300	45	101	1	600	0
	79	1.4	250	5	117	1	400	17	126	1	375	30	104	2	600	0
	78	0.4	264	9	114	2	450	33	125	0	360	15	100	2	600	0
Average	77.6		255		116		417		125		345		102		600	
Deviation in Laboratory		±1.45 per cent		±2.21 per cent		±1.14 per cent		±5.35 per cent		±0.8 per cent		±8.61 per cent		±1.62 per cent		±0.00 per cent

TABLE IV.—VARIATION OF INDIVIDUAL TEST VALUES IN THE SAME LABORATORY IN COMPARATIVE TESTS OF RESISTANCE TO EMULSIFICATION AND HERSCHEL DEMULSIBILITY. (*Continued.*)

Laboratory	Sample 25–5				Sample 25–6				Sample 25–7				Average of 7 Samples	
	A.S.T.M Steam Emulsion		Herschel Demulsibility, 130° F.		A.S.T.M. Steam Emulsion		Herschel Demulsibility, 130° F.		A.S.T.M. Steam Emulsion		Herschel Demulsibility, 130° F.		A.S.T.M. Steam Emulsion	Herschel Demulsibility, 130° F.
	Value, seconds	Deviation, seconds	Value, cc. per hour	Deviation, cc. per hour	Value, seconds	Deviation, seconds	Value, cc. per hour	Deviation, cc. per hour	Value, seconds	Deviation, seconds	Value, cc. per hour	Deviation, cc. per hour		
D	...	..	...	..	...	..	...	...	20	3	....	...	5.58 per cent	6.05 per cent
	...	..	...	..	...	..	...	..	18	5	1560	100		
	...	..	...	..	...	..	...	..	25	2	1220	440		
	...	..	...	..	...	..	...	..	20	3	1950	290		
	137	4	214	0	172	7	150	7	30	7	1620	40		
	144	3	214	0	185	6	136	7	20	3	1950	290		
Average	141		214		179		143		23		1660			
Deviation in Laboratory		±2.41 per cent		±0.00 per cent		±3.63 per cent		±4.90 per cent		±16.66 per cent		±14.00 per cent		
F	...	....	...	...	...	..	....	...	..	...	...	...	4.71 per cent	13.58 per cent
	120	10	1500	480	181	6	1080	168	24	3.2	810	48		
	135	5	1200	180	164	11	780	132	29	1.8	900	138		
	124	6	600	420	185	10	900	12	25	2.2	600	162		
	135	5	900	120	184	9	900	12	28	0.8	600	162		
	135	5	900	120	160	15	900	12	30	2.8	900	138		
Average	130		1020		175		912		27.2		762			
Deviation in Laboratory		±4.77 per cent		±25.88 per cent		±5.83 per cent		±7.37 per cent		±7.94 per cent		±15.69 per cent		
G	110	2	600	0	170	1	120	0	62	1	660	23	1.29 per cent	3.11 per cent
	105	3	570	30	170	1	120	0	64	1	690	7		
	109	1	630	30	168	1	120	0	62	1	700	17		
Average	108		600		169		120		63		683			
Deviation in Laboratory		±1.85 per cent		±3.33 per cent		±0.59 per cent		±0.00 per cent		±1.59 per cent		±2.29 per cent		
Average	......	......	......	......	......	......	......	......	......	......	......	......	3.86 per cent	7.58 per cent

with the Herschel Demulsibility Test. This is agreed to by all the collaborators who are thoroughly acquainted with the technique of both methods.

In answer to some comments regarding both methods the following should be noted:

Neither method absolutely parallels the condition in a turbine. However, the Steam Emulsion Test does duplicate in some respects the fine condensation of water, and the steam leaks through the seal into the oil in the same way as in service. Also this test tends to produce a stiff water-in-oil emulsion which is similar to the emulsion found in actual service and which causes trouble. This type of emulsion is apparently different from that produced by the Herschel Demulsibility Test.

The variations from slight inaccuracies in measuring the amount of oil and the fact that in some instances the time required for separation of the last 0.5 cc. is relatively large, have already been taken care of in that when taking the reading we have a net volume of oil greater than 20 cc. due to expansion. Therefore, not measuring the last portion slowly settling out really measures at about the 95 per cent point.

Regarding the deviation of results, it is necessary to know how to run the method and to follow the rules given. Care and experience will bring good results as already shown in this report.

A statement has been made that the Steam Emulsion Test does not give results which are linear with the degree of refinement with an oil, but neither does the Herschel Demulsibility Test, and no other method is known which will. The Herschel Demulsibility Test does not show gradation above 1620, while the Steam Emulsion with the present method of reading does show finer gradation.

FUNK SLUDGE ACCELERATOR TESTS

Representatives of two oil companies and three large consumers of turbine oils participated in the series of Funk Sludge Accelerator Tests. A description of the method of running these tests is appended to this report.

This machine has been called an oil sludging machine because of the common terminology applied to the deposit formed in the turbine reservoirs, throughout its lubricating system. It is felt, however, that this is a misnomer since this deposit consists chiefly of an emulsion found generally with a very small amount of sludge, which is the result of oxidation and deterioration of turbine lubricating oils under usual operating conditions.

Table V gives results obtained after running sludging machine test with addition of water. The sludge obtained after running these tests has been in such small amounts that it is practically negligible, while the combined sludge and emulsion is measurable. Last year, when running some of these tests, it is quite possible that some of sludge reported was probably iron rust. This is due to oxidation attack of air and water on the machine. At first it was thought that possibly some condition in the oil might have caused it, but this theory was disproved due to the deposition of iron rust when all seven samples of oil were tested and found by all operators testing the samples.

From the tabulated report of these tests the results show a fair agreement by all laboratories, with the exception of Laboratory J, for all oils tested, and this laboratory showed results consistently higher on all oils.

TABLE V.—RESULTS OF FUNK SLUDGING MACHINE TESTS AFTER RUNNING FIFTY HOURS WITH ADDITION OF WATER.

All values given are in terms of per cent.

	Sludge and Emulsion					Sludge					Emulsion				
	Laboratory G	Laboratory C	Laboratory I	Laboratory K	Laboratory J	Laboratory G	Laboratory C	Laboratory I	Laboratory K	Laboratory J	Laboratory G	Laboratory C	Laboratory I	Laboratory K	Laboratory J
Sample No 1	6.0	No Report	2.60	1.30	9.50	0.15	0.20	0.1	0.12	0.40	5.85	No Report	2.50	1.18	9.10
Sample No. 2	5.0		4.075	2.7[a]	16.00	0.25	0.20	0.75	0.06[a]	1.50	4.75		4.00	2.64[a]	14.50
Sample No. 3	5.0		4.10	5.0[a]	18.00	0.10	0.30	0.10	0.22[a]	1.00	4.90		4.00	4.78[a]	17.00
Sample No. 4	5.0		3.20	...	9.50	0.15	0.20	0.20	....	0.90	4.80		3.00	....	8.6
Sample No 5	4.0		3.60	4.2	5.00	0.20	0.20	0.10	0.058	0.35	5.80		3.50	4.142	4.65
Sample No. 6	6.0		4.075	3.5	7.00	0.28	0.20	0.75	0.09	0.80	5.78		4.00	3.41	6.20
Sample No. 7	1.50		2.56	3.15	4.00	0.15	0.10	0.06	0.10	0.35	1.35		2.50	3.05	3.65

[a] Duration of run 35 hours.

All laboratories, with the exception of one, rate oil 25-7 as the best in its own series of tests. This same oil has been shown by both Steam Emulsion and Herschel Demulsibility Tests the best oil by all laboratories except one. This one laboratory showed it to be best by the Steam Emulsion Test, but ranked it third from the poorest by the Herschel Test. In addition to these tests, oil 25-7 has been proved to be an exceptionally good oil after years of service.

All laboratories making the Sligh Oxidation Tests obtain results generally bearing out the above tests. These are shown in Table VI. Only a few laboratories reported on this test.

Conclusion from Results of Sludging Machine Tests.—The sludging machine or possibly more properly emulsion machine, is not intended to take the place of the Steam Emulsion or Herschel Demulsibility Test. It was developed to test out large samples of oil under conditions similar to those found in a turbine. The results obtained in this series of tests have shown only a fair agreement, and finer gradation is obtained with the Steam Emulsion Test.

Future Work.—A series of two or three more oils of different base crudes will be sent out for the purpose of having the same tests made upon them. Arrangement has already been made for this work.

TABLE VI.—SLIGH OXIDATION TESTS. RESULTS REPORTED AS OXIDATION NUMBER.

Laboratory	Sample 25-1	Sample 25-2	Sample 25-3	Sample 25-4	Sample 25-5	Sample 25-6	Sample 25-7
A	36	....	....	50	54	42	....
	42	....	....	54	48	39	....
	36	....	....	47	33	27	....
Average	35			50	45	36	
C	....	....	....	48	31	64	....
	....	....	....	56	43	50	....
Average				52	37	57	
D	....	....	....	49.8	46.6	51.3	....
	....	....	....	48.5	46.4	48.1	....
	....	....	....	46.3	44.8	44.4	....
	....	....	....	48.1	52.3	50.6	....
Average	38.6	28.8	30.8	48.2	47.5	48.6	28.0
G	85.1	46.2	88.8	63.2	56.6	70.0	42.2
	72.7	56.0	79.0	62.0	56.3	61.0	45.3
	82.1	55.9	76.0	70.1	49.9	62.0	40.9
Average	80	52.4	81.3	65.1	54.3	61.3	42.8
H	33.3	27.2	24.5	47.9	53.3	53.7	27.7
	33.8	30.8	25.6	50.8	49.4	45.5	28.2
	33.6	32.9	25.0	58.3	51.0	47.5	27.6
Average	33.6	30.3	25.0	52.3	51.2	48.9	27.6
I	....	....	....	38.0	43.3	42	....
	32.9	25.7	24.1	46.2	42.5	42.9	27.7
	35.3	24.5	24	45.2	43.7	41.4	28.9
Average	34.1	25.1	24.1	43.1	43.3	42.2	28.3

The chairman wishes to take this opportunity to thank all the members of the sub-committee and the representatives of the electric companies who have so kindly cooperated in these tests and especially Mr. Funk, as he has devoted much personal time to the work.

Respectfully submitted on behalf of the sub-committee,

JAMES T-B. BOWLES,
Chairman.

APPENDIX

DIRECTIONS FOR RUNNING 50-HOUR TEST WITH FUNK SLUDGE ACCELERATOR

Fill the thoroughly cleaned machine with 30 liters of oil and 3 liters of distilled water. Bolt on the cover, open the filling valve, and start the circulating pump. Light the burners (which should be placed under the oil inlet compartment to minimize bumping). Heat the mixture to 205° F. (96° C.) in 45 minutes, close the filling valve when this temperature is reached, and turn on the air (the rate of flow to be 40 liters per hour). Maintain the temperature at 205° F. (96° C.) during the operation of the machine.

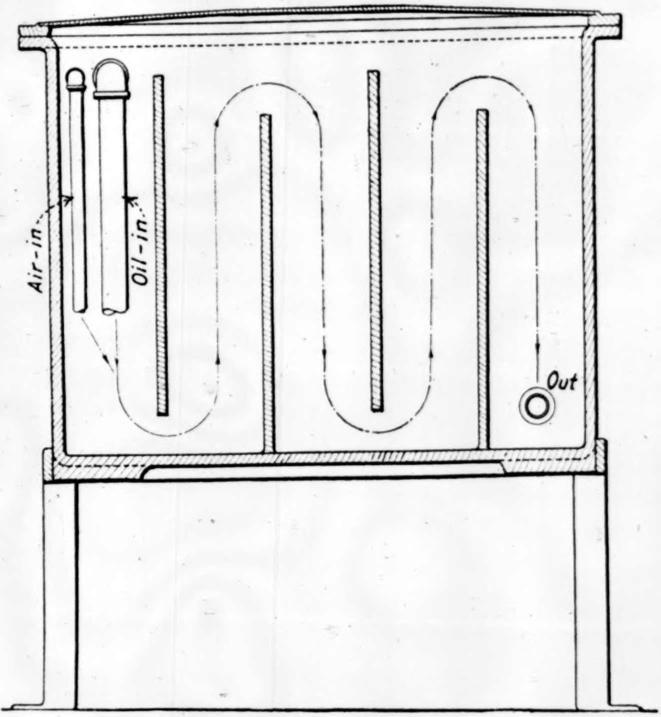

FIG. 1.—Funk Sludge Accelerator.

Draw the first sample one hour and other samples at 5-hour intervals after turning on the air. In drawing samples, draw off 100 cc. and return this to the machine. Then draw two 100-cc. samples directly into the centrifuge tubes. The tubes shall be immediately centrifuged at 1500 r.p.m. for ten minutes and the volume of sludge and emulsion read. The volume of the sludge and emulsion layer divided by the volume of the clear oil layer is reported as per cent of sludge and emulsion. Decant 50 cc. of the oil layer from each tube, add 25 cc. of 95-per-cent alcohol and 25 cc. of benzol (80–82° C.) to each tube, shake thoroughly, and centrifuge 10 minutes. The volume of the precipitated sludge divided by the volume of the clear oil layer secured in the first centrifuging is recorded as the percentage of sludge. In each case, the average of the results secured from the two samples is reported.

The machine shall be shut down and the burners turned off at least 8 hours out of every 24 hours. At these times the excess water which will have collected in the bottle through which the outgoing air is passed shall be returned to the machine.

NOTE:—In some oils the benzol-alcohol mixture does not completely precipitate the sludge. In such cases, addition of 15 cc. of acetone with thorough shaking and 5 minutes further centrifuging is effective in precipitating the sludge.

REPORT OF SUB-COMMITTEE XIII ON NEUTRALIZATION NUMBER AND SAPONIFICATION

The sub-committee has continued its study of the electrometric titration method for neutralization number.

One laboratory set up the apparatus for electrometric titration as described in an appendix to the report of the sub-committee for 1925[1] and examined oils of known high neutralization number by this method and by the A.S.T.M. Tentative Method of Test for Free Acid in Lubricants (D 188 – 25 T) with results as follows:

	Neutralization Number, mg. KOH per 1 g. of oil									
	A.S.T.M. Procedure (Method D 188 – 25 T)					Electrometric Procedure				
	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5
	1.32	0.963	1.287	1.436	0.022	1.450	1.414	1.324	1.469	0.019
	1.529	1.320	1.353	1.408	0.017	1.486	1.365	1.285	1.459	.....
Average	1.42	1.14	1.32	1.42	0.02	1.47	1.39	1.31	1.46	0.02

Oil Sample No. 1.—Serviced and dirty transformer oil.
Oil Sample No. 2.—Turbine oil from sludging accelerator.
Oil Sample No. 3.—Same as Sample No. 2.
Oil Sample No. 4.—Same as Sample No. 2.
Oil Sample No. 5.—Lubricating oil 25–4.

NOTE: On sample No. 5, a KOH solution of 1 cc. = 0.19 mg. KOH was used.

Samples 1, 2 and 3 were difficult to titrate by the A.S.T.M. method, due to the masking of the end point. The end point in oil Sample No. 2 was guessed.

An alkali solution $N/56$ (1 cc. = 1 mg. KOH) was suggested as being most suitable for ordinary oils, and $N/112$ (1 cc. = 0.5 mg. KOH) for high acid oils.

Another laboratory attempted the standardization of aqueous solutions of acids and alkalies by the electrometric procedure, from which the following conclusions are drawn:

1. The agar-agar cell should contain the salt formed when an acid is titrated with an alkali or *vice versa*.
2. Carbon dioxide is interfering.
3. A solution of the salt formed during the titration should be added to the cell and beaker before the titration is begun.
4. The concentration of the solutions added to the cell and beaker should be alike.

This laboratory reported lack of success on titration of oils.

Tentative Method of Test for Neutralization Number (D 188 – 25 T): Electrical insulating oils, new and serviced, have a neutralization number which is very low, on new oils below 0.10 mg. KOH. Three laboratories reported results using their own solutions and their own oils. Apparently the concentration of the alkali, the nature of the solvent, and its volume are factors which require further study so that the method may be applied to all petroleum products. The following are the results reported by Laboratory A.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 282 (1925).

Method	Neutralization Number, mg. KOH per 1 g. of oil					
	Sample No. 1	Sample No. 2	Sample No. 3	Sample No. 4	Sample No. 5	Sample No. 6
A.S.T.M. Method	1.28	0.13	0.16	0.26	0.17	0.38
General Electric Co. Method	1.78	0.19	0.23	0.26	0.48	0.57
Italian Sludge Method	0.59	0.016	0.016	0.094	0.094	0.094

NOTE.—In the General Electric Co. Method, 50 cc. of benzol is mixed with 50 cc. of alcohol, solvent neutralized with $N/100$ NaOH to phenolphthalein end point, added to 20 cc. of oil, and titrated with $N/100$ NaOH, aqueous solution. The values are calculated to milligrams of KOH.

Italian Sludge Method, not stated.

Nature of oils not stated.

The G. E. Co. Method in general shows a higher neutralization value. The Italian method shows unusually low values.

Laboratory B obtained consistently higher results for neutralization number on insulating oils using G. E. Co. Method, and $N/100$ NaOH aqueous solution, as compared to $N/10$ KOH A.S.T.M. procedure.

Laboratory C compared the A.S.T.M. method and the G. E. Co. Method and various modifications with the following results:

Method	Solvent 1:1	Volume of Solvent, cc.	Alkali	Normality	Neutralization Number, mg. KOH per g. of oil							
					No. 1, New Transformer Oil	No. 2, Serviced Transformer Oil	No. 3, Serviced Transformer Oil	No. 4, Serviced Transformer Oil	No. 5, New Turbine Oil	No. 6, Serviced Turbine Oil	No. 7, Serviced Turbine Oil	No. 8, Serviced Turbine Oil
A.S.T.M.	Alcohol and Water	50	KOH	0.1N	0.01	0.06	0.09	0.13	0.01	0.11	0.76	1.30
No. 1	Alcohol and Water	50	KOH	0.01N	0.02	0.09	0.07	0.13	0.01	0.11	0.63	1.10
No. 2	Alcohol and Benzol	50	KOH	0.1N	0.03	0.08	0.14	0.18	0.03	0.16	0.87	1.63
No. 4	Alcohol and Benzol	100	KOH	0.01N	0.03	0.10	0.15	0.18	0.05	0.16	0.96	1.80
No. 5	Alcohol and Benzol	100	KOH	0.01N	0.05	0.11	0.15	0.19	0.06	0.26	0.91	1.50
No. 3	Alcohol and Benzol	50	NaOH	0.01N	0.04	0.11	0.12	0.13	0.05	0.15	0.78	1.13
G. E. Co.	Alcohol and Benzol	100	NaOH	0.01N	0.05	0.10	0.11	0.18	0.04	0.16	0.84	1.30

NOTE.—All titrating solutions are aqueous.

Comments.—This laboratory experienced difficulty in neutralizing the benzol alcohol solvent to a definite conclusive and permanent end point using phenolphthalein as an indicator and $N/100$ NaOH as the alkali. The end point faded within 30 seconds.

In all procedures a two phase liquid was encountered, color change noted in alcohol layer. Oils 7 and 8 were very dark.

A.S.T.M. Method.—Severe emulsion with oils 7 and 8.

Method No. 1.—Severe emulsions in oils 7 and 8. The use of $N/100$ alkali does not permit of detection of a sharp clear end point in high acid oils. The end point faded rapidly in all oils.

G. E. Co. Method.—Emulsion formed in all oils, most severe in oils 7 and 8. Color change was indistinct due to slow settling of emulsion, and color of the oils used.

Method No. 2.—The end point was more difficult to detect than with A.S.T.M. method, and less difficult with G. E. Co. Method. A general emulsion formed as in the G. E. Co. Method. Less water is added to the oil due to the stronger alkali used.

Method No. 3.—See remarks under Method No. 2.

Method No. 4.—See remarks under Method No. 2. The emulsion was less troublesome due to greater strength alkali.

Method No. 5.—See remarks under G. E. Co. Methods.

Standardization.—The alkali solutions used by Laboratory C were standardized by using the required weight of benzoic acid (U. S. Bureau of Standards) dissolving the acid in the particular solvent used. The reagents used were:

Grain Alcohol, 95 per cent
Benzol, c.p.
Distilled Water
KOH, c.p.
NaOH, c.p.

Conclusions.—For new and serviced oils, having a neutralization number less than 0.15 mg. KOH, it is apparent that a definite positive deviation is noted from the A.S.T.M. values, in which the solvent dilution of the oils and normality of the alkali may be factors.

Another laboratory reported an apparent difficulty in neutralizing the benzol alcohol solvent.

It is significant therefore that the work of this sub-committee should develop:

1. The use of a solvent suitable for petroleum products, both new and serviced.
2. Determine the suitable normality of the titrating solution, and whether it be aqueous or alcoholic.

Suggested solvents are:
Alcohol and water, ethyl and methyl, 95 per cent.
Alcohol and benzol.
Straight run gasoline.

Suggested normalities are:
1 cc. = 1 mg. KOH
1 cc. = 2.5 mg. KOH
1 cc. = 5.0 mg. KOH

Suggested indicators are:
Phenolphthalein paper instead of solution.

Respectfully submitted on behalf of the sub-committee,

MAX HECHT,
Chairman.

REPORT OF SUB-COMMITTEE XXV ON CRANKCASE DILUTION

Sub-Committee XXV has conducted a series of experiments to determine the suitability of the so-called capillary funnel-bubble method for determining the percentage of dilution in used crankcase lubricating oils.

Method.—The method tried out was covered by detailed directions, not as yet published. The essential details are as follows:

> The apparatus was as far as possible identical with that specified in the Tentative Methods of Testing Gas Oils (D 158 - 25 T). This method in turn involves apparatus identical in many respects with that of the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (D 86 - 25 T). The essential feature of the method is the estimation of the percentage of dilution in terms of the volume of distillate collected in the receiving cylinder when the stream of liquid flowing from the condenser tip, through a special capillary funnel, ceases to entrain air bubbles. This cessation is, of course, due to the marked difference in viscosity between the heavier fractions of the diluent and the lighter fractions of the lubricating oil itself.

Experimental Procedure.—Six samples of lubricating oil were sent by the chairman to each of the laboratories cooperating in the tests. These samples, which are believed to be representative of practically all the types of crankcase lubricating oil marketed to any large extent in this country, were as follows:

A. A distillate lubricating oil of about 300 viscosity at 100° F. (37.8° C.) derived from Gulf Coast Crude Petroleum.
B. A distillate lubricating oil of about 300 viscosity at 100° F. (37.8° C.) derived from Mid-Continent Crude Petroleum.
C. A distillate lubricating oil of about 60 viscosity at 210° F. (98.9° C.) derived from Mid-Continent Crude Petroleum.
D. A distillate lubricating oil of about 60 viscosity at 210° F. (98.9° C.) derived from Gulf Coast Crude Petroleum.
E. A blend of Mid-Continent distillate lubricating oil with filtered cylinder stock, having a viscosity of about 300 at 100° F. (37.8° C.).
F. A blend of Gulf Coast distillate lubricating oil and filtered cylinder stock, having a viscosity of about 60 at 210° F. (98.9° C.).

With the lubricating oil samples was sent a supply of special naphtha which had a low percentage of fractions distilling below 212° F. (100° C.) and directions to make tests on mixtures of 5, 10, and 20 per cent of the naphtha with 95, 90 and 80 per cent respectively of each of the oils. The results obtained appear in the following table:

RESULT OF TESTS USING CAPILLARY FUNNEL-BUBBLE METHOD FOR DETERMINING CRANKCASE DILUTION

	Oil A	Oil B	Oil C	Oil D	Oil E	Oil F
TESTS ON MIXTURES OF 95 PER CENT OIL AND 5 PER CENT DILUENT						
Laboratory 1	5.2	5.2	5.2	5.2	5.2	5.2
Laboratory 2	4.5	5.0	4.7	4.5	4.7	4.5
Laboratory 3	5.0	5.6	7.6	5.4	5.2	5.2
Laboratory 4	5.0	6.0	6.0	4.5	5.0	4.5
Laboratory 5	5.5	5.0	7.0	5.1	6.3	5.3
Laboratory 6	4.5	5.0	5.5	4.0	5.0	4.0
Laboratory 7	6.0	8.5	32.0	7.5	6.5	6.0
Average	5.1	5.8	9.7	5.2	5.4	4.9
TESTS ON MIXTURES OF 90 PER CENT OIL AND 10 PER CENT DILUENT						
Laboratory 1	10.2	10.2	10.2	10.2	10.2	10.2
Laboratory 2	9.5	9.5	9.7	9.0	9.0	9.2
Laboratory 3	9.3	10.9	10.8	10.2	10.2	10.8
Laboratory 4	10.5	11.5	11.0	9.5	10.0	10.0
Laboratory 5	11.0	11.5	14.6	11.0	10.9	11.6
Laboratory 6	10.0	10.0	11.0	10.0	11.0	10.5
Laboratory 7	10.0	12.5	20.0	11.0	11.0	11.0
Average	10.1	10.9	12.4	10.1	10.3	10.5
TESTS ON MIXTURES OF 80 PER CENT OIL AND 20 PER CENT DILUENT						
Laboratory 1	20.2	20.2	20.2	20.2	20.2	20.2
Laboratory 2	18.2	19.0	19.2	18.2	18.5	18.0
Laboratory 3	20.3	20.4	22.7	20.0	20.2	20.0
Laboratory 4	20.0	20.5	20.5	19.5	20.0	20.5
Laboratory 5	20.0	20.7	22.0	20.0	20.2	20.1
Laboratory 6	20.0	21.0	20.0	20.0	20.0	20.0
Laboratory 7	20.5	23.0	32.0	21.0	20.5	22.0
Average	19.9	20.7	22.3	19.8	19.9	20.1

These figures indicate that the method, as tried, is reasonably accurate but that the procedure has not as yet been defined closely enough to prevent the possibility of unsatisfactory results from inexperienced operators. The major source of inaccuracy seems to be due to "cracking" of the lubricating oil when the rate of heating is too slow. It seems probable that better directions to cover this matter of heating would obviate some of the difficulties encountered in the present experiments.

It has been stated in the past that oils of low flash point, which of course means oils containing fractions of relatively low boiling point, and oils containing cylinder stock are most likely to give inaccurate results in a dilution test. The present experiments indicate that high flash oils are most likely to be the worst offenders as indicated by the high (in some instances abnormal) results obtained with oil C, which is a high-flash-point product. Oil B which is the next highest in flash gives the next highest results in the dilution tests.

It is felt that more experimental work needs to be done before offering a tentative method for publication. The method already studied will be tried again after revising directions in accordance with the needs pointed out by the results already obtained. In addition work will probably be done with another method which one of the members of the sub-committee has found particularly satisfactory.

Respectfully submitted on behalf of the sub-committee,

ROGER CHEW,
Chairman.

REPORT OF SUB-COMMITTEE XXVI ON PETROLEUM WOOD PRESERVATIVES

Sub-Committee XXVI has conducted experiments aimed primarily toward the establishment of a standard method for the separation of petroleum oils from coal-tar hydrocarbons. In all, a series of seven samples, consisting of two petroleum oils, two oils of coal-tar origin, and three mixtures, were tested, using two methods (1) solubility in di-methyl sulfate, and (2) solubility in sulfoacetic acid, in accordance with the method of H. Kattwinkel, suggested by Mr. Drefahl. In practically every case, unsatisfactory results were obtained due very probably to the nature of the petroleum oils used in the preparation of samples. These oils were residual fuel oils from California Crude Petroleum, having viscosities of 2 and 3° Engler, respectively.

The asphaltic nature of these oils precludes the possibility of making a determination of their solubility in either of the reagents used, although results obtained on mixtures would indicate that this was comparatively high.

It is felt that much experimental work must be done before offering a tentative method for adoption. The present methods, using the two reagents already suggested, will be subjected to further trial on the same and other samples, with a view to developing a satisfactory procedure.

Respectfully submitted on behalf of the sub-committee,

J. B. Terry,
Chairman.

SUB-COMMITTEE XXVII ON APPLICATION OF TESTS

The Sub-Committee on Application of Tests is preparing a report on the testing of petroleum products, covering in general:

1. An explanation of what is meant by the property or characteristic of the petroleum product to be evaluated, including definitions of terms employed;
2. The scope or applicability of the various methods for determining the property or characteristic in question; and
3. The significance and interpretation of results.

The preparation of this material involves a large amount of work. It is well under way, however, and it is expected that the report will be completed by the 1927 annual meeting.

Respectfully submitted on behalf of the sub-committee,

C. A. Lunn,
Chairman.

REPORT OF COMMITTEE D-4

ON

ROAD AND PAVING MATERIALS

Committee D-4 has held three meetings during the past year. Two new specifications, two new methods of testing have been prepared, and a number of existing tentative and standard specifications and methods of test have been revised.

Sections of the Sub-Committee on Bituminous Materials have been especially active and the investigations of two of these sections are believed to be of such value as to warrant printing their findings as appendices to this report.

During the year a Special Committee on Classification of Material According to Size was appointed to review the existing tentative specifications involving this subject, for which Committee D-4 was responsible, and to bring in recommendations as to the general policy which should be followed. As a result of the Special Committee's report, the following recommendations were adopted by letter ballot.

1. Committee D-4 reaffirms its stand in favor of screens with round openings for classifying materials larger than 4-mesh in size.

The vote on this is 36 affirmative; 4 negative; 26 not voting.

2. Committee D-4 will adhere to its present practice of preparing separate specifications for mineral aggregates for different uses but the number of separate specifications will be limited to such types of construction as have marked or distinctive differences.

The vote on this is 38 affirmative; 1 negative; 27 not voting.

Committee D-4 has considered certain definitions proposed in the Annual Report of Committee E-8 on Nomenclature and Definitions and wishes to record the following action:

1. *Definition for "Screen (Sieve)."*—It is understood that Committee E-8 has revised Note 2 to read as follows:

> "Note 2.—In mechanical analysis testing work the term 'sieve' when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are rectangular. The term 'screen' when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are circular."

Committee D-4 approves the definition and notes as revised.

2. *Definition for "Sand."*—Committee D-4 approves this definition with an insertion relative to size to read as follows:

> "*Sand.*—The fine granular material (*usually less than ¼-in. diameter*) resulting from the natural disintegration of rock, or from the crushing of friable sandstone rocks."

3. *Definition for "Aggregate."*—Committee D-4 approves the definition for Aggregate proposed by Committee E-8 without change.

4. *Suggested definition for "Concrete."*—A letter ballot on this definition showed 26 voting affirmatively, 8 negatively and 34 not voting on the following note as a substitute for that published by Committee E-8:

> "NOTE.—The term 'concrete' without descriptive adjective is indefinite and unspecific and should be always used with a qualifying adjective indicating the cementing material, *i. e.*, asphaltic concrete, coal-tar concrete, portland-cement concrete, etc."

PROPOSED REVISIONS OF EXISTING STANDARD SPECIFICATIONS AND METHODS OF TEST

NO. 1. *Standard Method of Test for Abrasion of Road Material D 2 – 08).*[1]—The committee believes that the title of this standard should be made more specific in view of the fact that there are many road materials for which the test is unsuitable. It therefore recommends that the title be made to read as follows by the addition of the italicized word and the omission of the words in brackets:

"Standard Method of Test for Abrasion of *Rock* [Road Material]"

It is recommended that this revision be incorporated in the present standard method without publication as tentative. The committee accordingly asks for the necessary nine-tenths vote for adoption of this revision as standard immediately.

NO. 2. *Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (D 36 – 24).*[1]—In order to meet criticisms that have been received and to clarify the intent of this standard, the following revisions are recommended:

Section 4.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "4. [Assemble the apparatus as shown in Fig. 1.] Fill the glass vessel to a depth of substantially 8.25 cm. (3.25 in.) with freshly boiled distilled water at 5° C. (41° F.). [Place the ball in the center of the upper surface of the bitumen in the ring and suspend it.] *Suspend the ring containing the sample* in the water so that the lower surface of the filled ring is exactly 2.54 cm. (1 in.) above the bottom of the glass vessel and its upper surface is 5.08 cm. (2 in.) below the surface of the water. *Place the ball in the water but not on the specimen.* [Allow

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[1] 1924 Book of A.S.T.M. Standards.

it to remain in the water for 15 minutes before applying heat.] Suspend the thermometer so that the bottom of the bulb is level with the bottom of the ring and within 0.635 cm. (¼ in.) but not touching the ring. *Maintain the temperature of the water at 5° C. (41° F.) for fifteen minutes. With suitable forceps place the ball in the center of the upper surface of the bitumen in the ring, thus completing the assembly as in Fig. 1.*"

Section 8.—Change the first paragraph of this section to read as follows by the addition of the italicized words and the omission of those in brackets:

"[Use the] *The* same method as given under (A) *shall be employed* except that *U. S. P.* glycerin shall be used instead of water, and the starting point of the glycerin bath shall be 32° C. (89.6° F.). The bath shall be brought to this temperature and thoroughly agitated, then the apparatus and specimen shall be placed in the bath *which shall be maintained under agitation at the starting temperature for 15 minutes, after which the assembly shall be completed by placing the ball on the center of the specimen* and the test [proceed as usual.] *carried on as in (A).* In applying the heat, the ring apparatus shall be placed off the center of the container and the burner placed midway between the center and edge of the beaker away from the specimen."

It is recommended that these revisions be incorporated in the present standard method without publication as tentative. The committee accordingly asks for the necessary nine-tenths vote for adoption of this revision as standard immediately.

NO. 3. *Standard Specifications for Block for Granite Block Pavements (D 59 - 22).*[1]—During the past year, consideration was given to the preparation of specifications for a wider block than that covered in the present standard. It was finally decided however that, as all requirements other than width would be the same as given in the present standard, a slight revision of the standard specifications would accomplish the desired purpose and prevent unnecessary multiplicity. The following revision is therefore recommended:

Section 4.—Change the fourth line to read as follows by the addition of the italicized word and figures:

"Width on top, in.................. 3½ to 4½ *or 4 1/2 to 5 1/2*"

It is recommended that this revision be incorporated in the present standard without publication as tentative. The committee accordingly asks for the necessary nine-tenths vote for adoption of this revision as standard immediately.

NO. 4. *Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 18).*[1]—For some time past, the Sectional Committee on Distillation has been investigating various designs of distilling apparatus in an endeavor to improve the present standard method. As a result of this investigation it has developed an improved method which is appended hereto,[1] together with an explanatory report containing valuable research data.

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[1] 1924 Book of A.S.T.M. Standards.

It is recommended that this method be accepted as a revision of the present standard method and published as tentative.

PROPOSED REVISIONS OF TENTATIVE SPECIFICATIONS AND METHODS OF TEST

NO. 1. *Tentative Specifications for Asphalt Cement, 50 to 60 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 100 - 23 T)*[2] and *Tentative Specifications for Asphalt Cement, 60 to 70 Penetration, for Use in Sheet Asphalt, Asphaltic Concrete and Asphalt-Macadam Pavements (D 101 - 23 T)*.[3]—The following change in the title of each of these specifications is recommended:

After the word "Pavements" add "*and as Filler for Block Pavements*," and add the following footnote:

"For use as filler for block pavements, the asphalt should be mixed with a suitable proportion of sand."

It is recommended that these specifications as revised be continued as tentative.

NO. 2. *Tentative Specifications for Asphalt Cement, 40 to 50 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 99 - 23 T)*.[4]—The following revision of these specifications is recommended:

In the title after the word "Pavements" add "*and as Filler for Brick and Block Pavements*," and add the following footnote:

"As a filler the asphalt cement is not to be used in admixture with sand."

It is recommended that these specifications as revised be continued as tentative.

NO. 3. *Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (D 70 - 20 T)*[5] and *Tentative Method of Test for Specific Gravity of Asphalts and Tar*

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[1] See p. 881.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 726 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 459.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 727 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 460.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 725 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 458.

[5] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 764 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 482.

Pitches Sufficiently Solid to be Handled in Fragments (D 71 - 20 T).[1]—In order to make these tests conform with the definition for specific gravity recommended by Committee E-8 on Nomenclature and Definitions, the following slight revision is recommended in each case:

Section 1.—Change the last line to read as follows by the omission of the figures in brackets:

> "Specific gravity 25° [/25°] C. (77° [/77°] F.)"

While the committee feels that these methods are now in suitable shape for advancement to standard, in view of the fact that a new book of standards will not be published until 1927, it is recommended that the methods as revised be continued as tentative.

No. 4. *Tentative Method of Test for the Determination of Bitumen (D 4 - 23 T).*[2]—The following slight revision of this test is recommended:

Section 5.—Change the first sentence of the second paragraph to read as follows by the addition of the italicized words:

> "The Gooch crucible shall be set up again with the suction flask and the carbon disulfide solution carefully decanted through the asbestos felt, *with or without light suction as may be found necessary.*"

While the committee feels that this method is now in suitable shape for advancement to standard, in view of the fact that a new book of standards will not be published until 1927, it is recommended that the method as revised be continued as tentative.

No. 5. *Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (D 165 - 23 T).*[3]—The same revision of this test is recommended as in the preceding test.

Section 4.—Make the same change as in Section 5 of Method D 4 - 23 T above.

While the committee feels that this method is now in suitable shape for advancement to standard, in view of the fact that a new book of standards will not be published until 1927, it is recommended that the method as revised be continued as tentative.

No. 6. *Tentative Method of Test for Ductility of Bituminous Materials (D 113 - 22 T).*[4]—In order to meet criticisms which have been received the following revisions of this test are recommended:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 767 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 485.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 751 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 496.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 754 (1923); also 1925 Book of A.S.T.M. Tentative Standards, p. 499.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 807 (1922); also 1925 Book of A.S.T.M. Tentative Standards, p. 501.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"The ductility of an asphalt cement or semi-solid bitumen is *measured by* the distance to which it will elongate before breaking when two ends of a briquet of the material are pulled apart at a specified rate of speed and at a specified temperature [. When the conditions of the test are not specifically mentioned, the rate and the temperature are understood to] , *which for a normal test shall* be 5 cm. per minute at 25° C. (77° F.)."

Section 7.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"The rings at each end of the clip shall then be attached to the pins or hooks in the ductility machine and the two clips pulled apart at a uniform rate of 5 cm. per minute (± 5 per cent) *until the briquet ruptures. The distance through which the clips have been pulled to produce rupture shall then be measured in centimeters.* While the test is being made, the water in the tank of the ductility machine shall cover the sample by at least 2.5 cm. and shall be kept continuously at a temperature within 0.5° C. of 25° C. (77° F.). [When the specimen of bituminous material breaks, the distance from the original position of the clip before pulling to its present position shall be measured, and shall be known as the ductility. The average of three tests shall be taken, excepting that any abnormal result shall be rejected.]

"*A normal test is one in which the material between the two clips pulls out to a point or thread until rupture occurs at the point where the thread has practically no cross-sectional area. The average of three normal tests shall be taken and reported as the ductility of the sample.*

"*If a normal test is not obtainable on three successive tests, the ductility should be reported as being unobtainable under the conditions of the test.*"

It is recommended that this method as revised be continued as tentative.

NO. 7. *Tentative Method of Test for Consistency of Portland-Cement Concrete (D 138 – 25 T).*[1]—In order to make this test agree with the Standard Method of Making Compression Tests of Concrete (C 39 – 25) the following revision is recommended:

Section 4.—Change the second sentence to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"The mold shall be filled to about one-fourth of its height with the concrete which shall then be puddled, using [20 to 30] *25* strokes of a [½-in. rod] *⅝-in. rod, 2 ft. long, bullet*-pointed at the lower end."

It is recommended that this method as revised be continued as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 746 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 494.

PROPOSED WITHDRAWAL OF TENTATIVE METHOD OF TEST.

Tentative Method of Mechanical Analysis of Subgrade Soils (D 137 - 25 T).[1]—Because this method is now being discarded and there is considerable uncertainty as to what will be used in its place, the committee recommends that the tentative method be withdrawn.

TABLE I.

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF EXISTING STANDARDS			
Standard Method of Test for Abrasion of Road Material (D 2 - 08)	40	0	28
Standard Method of Test for Softening Point of Bituminous Materials (Ring and Ball Method) (D 36 - 24)	40	0	28
Standard Specifications for Block for Granite Block Pavements (D 59 - 22)	37	0	31
Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 18)	36	0	32
II. PROPOSED REVISION OF EXISTING TENTATIVE STANDARDS			
Tentative Specifications for Asphalt Cement, 50 to 60 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 100 - 23 T)	33	2	33
Tentative Specifications for Asphalt Cement, 60 to 70 Penetration, for Use in Sheet Asphalt, Asphaltic-Concrete and Asphalt-Macadam Pavements (D 101 - 23 T)	34	2	32
Tentative Specifications for Asphalt Cement, 40 to 50 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements (D 99 - 23 T)	33	2	33
Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (D 70 - 20 T)	37	1	30
Tentative Method of Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments (D 71 - 20 T)	37	1	30
Tentative Method of Test for the Determination of Bitumen (D 4 - 23 T)	39	0	29
Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (D 165 - 23 T)	38	0	30
Tentative Method of Test for Ductility of Bituminous Materials (D 113 - 22 T)	38	1	29
Tentative Method of Test for Consistency of Portland-Cement Concrete (D 138 - 25 T)	35	0	33
III. PROPOSED WITHDRAWAL OF EXISTING TENTATIVE STANDARD			
Tentative Method of Mechanical Analysis of Subgrade Soils (D 137 - 25 T)	36	0	32
IV. PROPOSED NEW TENTATIVE STANDARDS			
Specifications for Asphalt Filler for Brick Pavements (Blown Type)	34	2	32
Specifications for Mineral Filler for Sheet Asphalt and Bituminous-Concrete Pavements	27	5	36
Method of Test for Residue of Specified Penetration	33	3	32
Method of Test for Bituminous Emulsions	36	0	32

NEW SPECIFICATIONS, METHODS OF TEST AND RECOMMENDED PRACTICE SUBMITTED AS TENTATIVE.

The committee recommends for publication as tentative the following specifications and methods of test, appended hereto:[2]

1. Specifications for Asphalt Filler for Brick Pavements (Blown Type);
2. Specifications for Mineral Filler for Sheet Asphalt and Bituminous-Concrete Pavements;
3. Method of Test for Residue of Specified Penetration;
4. Methods of Testing Bituminous Emulsions.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 742 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 490.

[2] See pp. 866, 868, 889 and 894.—ED.

The results of letter ballot of the committee upon the recommendations made in this report are given in Table I.

This report has been submitted to letter ballot of the committee, which consists of 68 members, of whom 39 have voted affirmatively, none negatively, and 29 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. S. MATTIMORE,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Method of Test for Abrasion of Road Material; for Softening Point of Bituminous Materials (Ring-and-Ball Method); and of the Standard Specifications for Block for Granite Block Pavements were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926. The proposed revisions of the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment were accepted as new tentative methods and appear on page 881.

The proposed revisions of the Tentative Specifications for Asphalt Cement, 50 to 60 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements; for Asphalt Cement, 60 to 70 Penetration, for Use in Sheet Asphalt, Asphaltic Concrete and Asphalt-Macadam Pavements; for Asphalt Cement, 40 to 50 Penetration, for Use in Sheet Asphalt and Asphaltic-Concrete Pavements; and Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches; for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments; for the Determination of Bitumen; for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride; for Ductility of Bituminous Materials; and for Consistency of Portland-Cement Concrete were accepted. The tentative specifications and methods of test in their revised form appear on pages 860 to 865, 869 to 880 and 886.

On recommendation of the committee the withdrawal of the Tentative Method of Mechanical Analysis of Subgrade Soils was approved.

The proposed Tentative Specifications for Asphalt Filler for Brick Pavements (Blown Type); for Mineral Filler for Sheet Asphalt and Bituminous-Concrete Pavements; and the Tentative Method of Test for Residue of Specified Penetration; and for Bituminous Emulsions were accepted for publication as tentative and appear on pages 866, 868, 889 and 894, respectively.

APPENDIX I

REPORT OF SECTION ON DISTILLATION

During 1925 the Section on Distillation has done considerable work in studying the use of a distillation flask with a very short neck and a large take-off immediately above the body as compared with the Engler type of flask as used in the present Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 18). The flask under examination has been known as the Carey-Kerr or Church flask, but for the purpose of this report it is proposed to give it the name of E-1 flask as being simpler. The dimensions of this flask are shown in the accompanying Fig. 1.

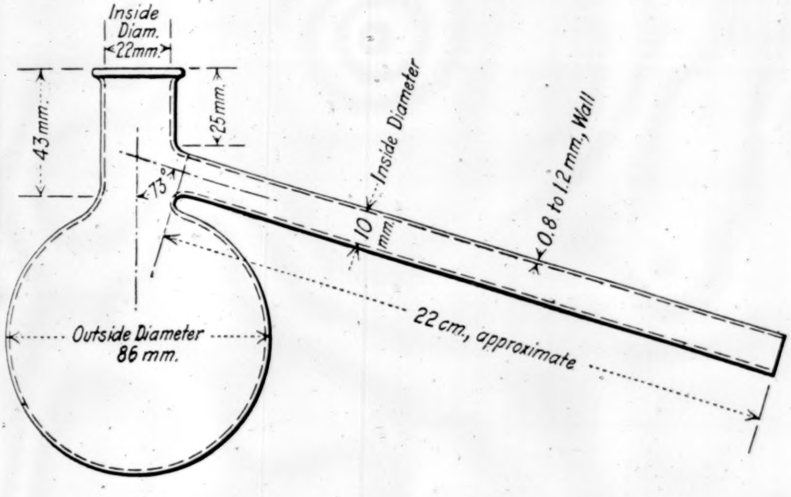

Fig. 1.—Distillation Flask.

Early in 1925 samples of material were sent out to a number of cooperators, but the directions for carrying on the experimental work were not sufficiently explicit so that some of the cooperators did not understand exactly what was wanted and in consequence the results were not all directly comparable. With this experience in mind, a second series of samples was sent out in April, 1925, and a very carefully prepared set of instructions accompanied these samples. It is believed that these instructions were sufficiently explicit so that no misunderstanding could take place. These instructions covered four methods of distillation, as follows:

Method A.—The present Standard Method D 20 – 18, modified with respect to the use of a higher rate of distillation and the position of the thermometer bulb.

Method B.—The E-1 flask with the thermometer in high position and using a creosote condenser.

Method C.—The E-1 flask with the thermometer in low position and using a creosote condenser.

Method D.—The E-1 flask with the thermometer in high position and using a short or D-4 condenser.

All of the details of these methods were very carefully worked out, including directions for checking the thermometers, handling the residue after distillation, determining the softening point and observing the barometric pressure.

TABLE I.—OBSERVATIONS ON THERMOMETERS AS USED IN METHOD A.

Laboratory	Boiling Point of Water				Boiling Point of Naphthalene			
	Barometer, mm.	Observed Temperature, deg. Cent.	Corrected Temperature, deg. Cent.	Difference, deg. Cent.	Barometer, mm.	Observed Temperature, deg. Cent.	Corrected Temperature, deg. Cent.	Difference, deg. Cent.
A	758.5	103.5	99.94	+3.6	758.5	216	217.85	−1.9
B	745	99.2	99.44	−0.2	745	214	216.95	−3.0
C	761.2	100	100.04	0.0	760.7	214	217.91	−3.9
D	760.7	113.5	100.03	+13.5	760.7	214	217.91	−3.9
E	760.7	113.5	100.03	+13.5	760.7	214	217.91	−3.9
F	728.0	101.5	98.82	+2.7	739.6	214	216.59	−2.6
G	743.66	100.3	99.40	+0.9	742.75	215	216.80	−1.8

Three samples of material were sent out to the cooperators, as follows:

Sample A.—Conforming to A.S.T.M. Specifications D 106 – 23 T.[1]
Sample B.—Conforming to A.S.T.M. Specifications D 104 – 23 T.[2]
Sample C.—Conforming to A.S.T.M. Specifications D 109 – 23 T.[3]

The samples of material were sent to eleven cooperators and six laboratories reported results, while one laboratory reported results from two operators. This report summarizes the results obtained.

THERMOMETER CHECKING

The present thermometer specifications do not require standardization by means of water, naphthalene and benzophenone although it was intended that such a provision should be added. It would accordingly appear that the majority of the laboratories were using uncorrected thermometers and were not making this standardization test. The Bureau of Public Roads, the State of New Hampshire and the United Gas Improvement Co. were apparently standardizing their thermometers with liquids of known boiling point and were using corrected thermometers. In view of the change made in the method, it was thought best to use the uncorrected thermometers but to ask the cooperators to check their thermometers with water and naphthalene as a means of indicating the comparative accuracy of the different thermometers used. These observations are given in Table I. The most striking results are the figures given for the boiling point of water where the difference between the observed and corrected boiling point varies from 0 to 13.5° C. This variation is obviously due to superheating. Some further work has been done in this connection by several of the cooperators. Mr. Gage found with the shield and boiling water a plus difference of 13.5° C., and that when the shield was removed the corrected difference was only +0.6° C.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 735 (1923).

[2] *Ibid*, p. 731.

[3] *Ibid*, p. 741.

Mr. Reeve reported two sets of observations as follows:

	BOILING POINT OF WATER	
	SET UP METHOD D 20 – 18	METHOD D 20 – 18 WITH WATER-COOLED CONDENSER
Reading at first drop	100.5° C.	100.5° C.
10 per cent	101.0° C.	101.0° C.
20 per cent	101.4° C.	101.2° C.
30 per cent	102.0° C.	101.8° C.
40 per cent	105.3° C.	102.2° C.
50 per cent	138.0° C.	103.5° C.

Mr. Anderton has also shown some interesting work with the following results:

	BOILING POINT OF WATER, D 20 – 18 SET UP		
	RUN A	RUN B	RUN C
Reading at first drop	100.0° C.	100.0° C.	100.0° C.
5 per cent	100.2° C.	100.5° C.	100.0° C.
10 per cent	102.0° C.	100.7° C.	100.0° C.
15 per cent	103.5° C.	102.6° C.	100.0° C.
20 per cent	104.8° C.	106.5° C.	100.2° C.
25 per cent	109.0° C.	108.0° C.	100.2° C.
30 per cent	....	....	100.2° C.
35 per cent	....	....	100.2° C.
40 per cent	....	....	100.2° C.
45 per cent	....	....	100.2° C.

In Runs A and B an aluminum disk was suspended $\frac{1}{4}$ in. below the thermometer. In Run C, 2 g. of lampblack were added to the 100 cc. of water in the flask.

Very evidently this matter will repay some further work and it has already been reported to Committee D-15 on Thermometers, which committee will look into the matter and endeavor to determine why such large differences may result from different operators.

It will be noted, however, that with naphthalene, there was not a great variation in the results obtained by different laboratories and

TABLE II.—RESULTS OF TESTS ON SAMPLE CONFORMING TO TENTATIVE SPECIFICATIONS FOR HIGH-CARBON TAR FOR SURFACE TREATMENT, COLD APPLICATION (D 104 - 23 T).

Laboratory	Barometer, mm.	Time to First Drop		Time, First Drop to 300° C.		Distillate, per cent by weight				Residue, per cent by weight	Softening Point of Residue, deg. Cent.
						100 - 170° C.	170 - 235° C.	235 - 270° C.	270 - 300° C.		
METHOD A											
		min.	sec.	min.	sec.						
A	766	7		23		0.4	11.1	11.1	7.3	69.3	42.5
B	762	6		20		1.0	11.1	11.5	6.8	69.7	42.6
C	760.7	6	30	13	4	0.8	12.3	11.0	6.8	69.1	41.0
D	758.5	22		47		1.1	9.1	12.7	7.0	70.0	41.7
E	761	10		23		0.7	8.7	13.0	7.3	68.4	45.6
F	739	5		23		0.2	11.2	11.8	7.4	69.1	43.0
G	745.5	4		20		0.7	10.4	10.7	7.6	70.2	41.2
METHOD B											
A	765.2	9		22		0.3	9.4	12.4	7.6	69.5	40.5
B	765.3	12	30	17	30	0.5	9.4	11.0	7.2	72.0	41.9
C	765.2	8	18	11	18	0.2	11.8	9.7	7.5	70.0	41.0
D	758	10		40	30	1.6	8.4	13.2	8.0	68.0	47.2
E	761	9	30	12		0.8	8.0	12.1	8.8	69.0	43.9
F	739	5	30	15		0.4	6.9	12.8	7.9	71.7	36.6
G	746.2	5		24		0.8	10.3	11.7	7.0	70.5	40.2
METHOD C											
A	765	6		12		0.3	7.1	12.1	7.4	71.4	37.5
B	765.3	7		18		0.2	7.8	11.6	8.4	72.0	39.7
C	763.2	6	8	11		0.4	7.9	12.2	7.2	71.5	39.0
D	754.9	11	30	17	30	0.6	8.6	11.5	7.5	70.8	38.3
E	754.9	8	30	10		0.5	8.8	11.1	8.2	70.7	37.8
F	738	6	30	18		0.3	5.1	12.4	8.6	73.2	33.0
G	745.9	8		21		0.4	6.8	12.1	7.4	73.3	36.9
METHOD D											
A	762	6		17		0.5	12.5	8.0	7.9	70.3	43.0
B	765.3	6		24		0.7	9.4	10.9	5.8	73.3	34.4
C	763.2	6	24	12	15	0.5	10.1	11.3	7.3	70.0	41.0
D	761.5	22		?		0.3	6.5	12.6	9.4	70.3	41.1
E	....	..	..	..	..	....	....	....	...	....	....
F	739	5		21	15	0.7	7.0	12.0	8.4	72.0	35.6
G	746.2	4		20		0.9	8.6	13.1	7.8	69.6	39.8

the figures obtained this year generally check those obtained in past tests, the average being 2.8° C. We would expect to have found about 3.3 to 3.5° C., and this indicates that the thermometers were probably all within 1° C. of being correct.

DISTILLATION RESULTS

The results of the distillation test are shown in Tables II to IV, inclusive, in which the fractions are reported as a percentage by weight. The average figures from these results are summarized again in Table V.

TABLE III.—RESULTS OF TESTS ON SAMPLE CONFORMING TO TENTATIVE SPECIFICATIONS FOR HIGH-CARBON TAR CEMENT FOR USE COLD IN REPAIR WORK (CUT-BACK PRODUCT) (D 106 – 23 T).

Laboratory	Barometer, mm.	Time to First Drop		Time, First Drop to 300° C.		Distillate, per cent by weight				Residue, per cent by weight	Softening Point of Residue, deg. Cent.
						100 – 170° C.	170 – 235° C.	235 – 270° C.	270 – 300° C.		
METHOD A											
		min.	sec.	min.	sec.						
A.........	766	4		20		3.8	11.7	5.7	4.5	74.0	57.5
B.........	749	5		17	45	3.3	12.3	4.8	5.5	74.1	57.8
C.........	759.5	6	30	11	5	2.7	11.8	5.4	4.9	75.2	57.0
D.........	759	20		19		3.1	11.9	4.8	5.8	74.8	56.1
E.........	761	8		11	30	3.3	11.8	5.6	5.3	73.3	57.8
F.........	725.5	5	15	19		3.6	12.1	5.8	5.0	73.9	59.4
G.........	747.5	3		23		2.8	12.0	5.1	5.6	75.4	54.8
METHOD B											
A.........	765	6		11		1.9	11.6	5.7	5.9	74.1	55.5
B.........	731.5	11	30	13	30	1.8	11.8	5.6	5.8	75.1	57.9
C.........	760.7	5	55	9	5	1.8	11.5	5.5	5.7	75.5	59.0
D.........	759	13		26		2.5	11.7	5.4	6.3	73.6	58.3
E.........	761	10		8		1.5	11.2	5.6	5.5	75.1	53.9
F.........	725	7	30	14		0.1	11.1	6.1	5.6	76.2	51.2
G.........	745.5	5		14		1.8	12.2	6.0	6.4	73.0	59.8
METHOD C											
A.........	764.5	4		12		2.2	11.0	5.1	5.6	75.5	53.5
B.........	757.4	7	30	11	30	1.3	10.9	5.2	4.0	78.7	49.0
C.........	760.7	5	18	9	51	2.1	10.9	4.9	5.6	76.0	54.0
D.........	754.9	20		25		1.4	11.9	5.1	5.4	76.2	52.2
E.........	760.6	8		14	30	2.3	11.8	5.1	5.5	75.5	51.7
F.........	727	4	15	10	30	0.0	9.6	7.1	5.8	76.8	49.6
G.........	745.3	5		19		1.8	11.3	5.0	4.8	76.8	51.7
METHOD D											
A.........	762	5		16		1.8	11.9	5.7	5.9	74.7	56.0
B.........	762	6	30	17	30	2.4	12.2	5.5	5.2	74.2	57.8
C.........	760.7	5	50	9	11	1.8	11.8	5.1	5.8	75.0	50.0
D.........	761.5	11		33		1.5	11.7	5.8	7.0	73.9	56.1
E.........	....	..		..		...	....	....	...	....	....
F.........	725	7		18		0.4	12.6	5.6	5.2	75.9	53.6
G.........	745.3	5		26		1.7	10.7	6.2	5.0	76.4	54.2

It would seem, speaking generally, that any one of the four methods of operation should give entirely satisfactory results as a working method. The choice of the method to be recommended would therefore depend, not upon the technical question as to the reproducibility of results, but upon more practical considerations as to which method would give greatest convenience in handling, cost of apparatus, space required, etc. In this connection, it would be well to quote some of the opinions as expressed by the operators.

TABLE IV.—RESULTS OF TESTS ON SAMPLE CONFORMING TO TENTATIVE SPECIFICATIONS FOR LOW-CARBON TAR FOR SURFACE TREATMENT, HOT APPLICATION (D 109 – 23 T).

Laboratory	Barometer, mm.	Time to First Drop		Time, First Drop to 300° C.		Distillate, per cent by weight				Residue, per cent by weight	Softening Point of Residue, deg. Cent.
						100 – 170° C.	170 – 235° C.	235 – 270° C.	270 – 300° C.		
METHOD A											
		min.	sec.	min.	sec.						
A.........	763	7		10		0.0	0.4	8.2	11.7	79.5	50.0
B.........	767.1	8		12		0.0	1.4	7.7	11.2	79.7	52.4
C.........	762.0	8	25	7	42	0.0	0.5	9.2	10.0	81.0	51.0
D.........	758	18		7		0.0	0.3	6.7	13.2	79.9	47.8
E.........	760.5	11		9		0.0	0.8	8.8	10.8	79.2	52.8
F.........	737	7		11	15	0.0	0.9	10.0	13.3	76.8	53.0
G.........	746.5	8		15		0.0	0.4	7.5	10.1	82.0	46.2
METHOD B											
A.........	764.5	9		5		0.0	0.0	5.7	13.1	80.7	48.5
B.........	767.1	11		8		0.0	0.0	6.9	12.5	80.7	52.4
C.........	762.2	11		6	13	0.0	0.0	6.8	12.5	80.0	51.0
D.........	756.9	24		19		0.0	1.4	5.3	11.9	81.1	47.2
E.........	760.5	11	30	6		0.0	1.4	4.6	11.3	82.2	46.7
F.........	737	8		8		0.0	0.0	5.1	13.7	80.9	47.2
G.........	746.5	12		11		0.0	0.0	7.0	12.3	80.7	49.0
METHOD C											
A.........	764.5	7		5		0.0	0.0	3.1	11.8	84.2	42.5
B.........	767.1	9	30	8		0.0	0.0	3.6	14.3	81.7	46.7
C.........	762.2	10		6	8	0.0	0.0	5.2	11.1	83.5	44.5
D.........	754.9	18	30	6		0.0	0.0	4.3	10.9	84.8	43.3
E.........	...	..		..		...	...	...	....	....	....
F.........	737	7	30	7	30	0.0	0.0	3.3	11.8	84.9	43.8
G.........	746.8	13		9		0.0	0.0	4.2	11.4	84.2	43.4
METHOD D											
A.........	763	10		13		0.0	0.0	7.5	11.3	81.0	48.0
B.........	767.1	9		10		0.0	0.0	7.5	10.9	81.6	47.3
C.........	762.2	9	5	6	30	0.0	0.0	6.6	12.1	80.5	49.0
D.........	760.5	22	30	10	30	0.0	0.6	5.2	11.9	82.0	47.2
E.........	...	..		..		...	...	...	....	....	....
F.........	738	11	30	12		0.0	0.1	4.8	14.8	80.3	48.4
G.........	746.5	14		12		0.0	0.0	7.0	11.9	81.1	48.6

Mr. Gage has very definite ideas and has expressed them as follows:

“The flask can be filled with the material to be distilled very much more readily and very much more handily than the standard flask.

“If the sample contains water, no noticeable disturbance occurs in the flask; that is, the water comes over without any fuss.

“The flask seems to be so much more durable and can be cleaned and handled very much better than the standard flask.”

Mr. Myers also prefers the Carey-Kerr flask "as it causes less trouble in the distillation of materials containing a few drops of water."

TABLE V.—AVERAGES AND MAXIMUM DEVIATIONS OF TEST RESULTS.

Method	Time to First Drop	Time, First Drop to 300° C.	Distillate, per cent by weight				Residue, per cent by weight	Softening Point of Residue, deg. Cent.
			100 - 170° C.	170 - 235° C.	235 - 270° C.	270 - 300° C.		
			SAMPLE, SPECIFICATIONS D 104 - 23 T AVERAGES					
	min. sec.	min. sec.						
A	8 36	24 6	0.7	10.5	11.7	7.2	69.4	42.5
B	8 24	20 18	0.5	9.2	11.8	7.7	70.1	41.6
C	7 42	15 24	0.4	7.4	11.8	7.8	71.8	37.4
D	8 18	18 54	0.5	7.7	11.1	7.7	70.8	39.1
			MAXIMUM DEVIATIONS					
A	+21 24	+22 54	−0.5	±1.8	+1.3	−0.5	+0.8	+3.1
B	+4 6	+20 12	+1.1	−2.3	−2.1	+1.1	−2.1	−5.0
C	+3 48	+5 36	±0.2	−2.3	−0.7	+0.8	+1.5	−4.4
D	+13 42	−6 36	+0.4	+4.8	−3.1	−1.9	+2.5	−4.7
			SAMPLE, SPECIFICATIONS D 106 - 23 T AVERAGES					
A	7 30	17 12	3.2	11.9	5.3	5.1	74.4	57.2
B	8 24	13 42	1.6	11.6	5.7	5.9	74.7	57.9
C	7 42	14 36	1.6	11.0	5.3	5.2	76.7	52.0
D	6 42	19 54	1.7	11.8	5.7	5.7	75.0	54.6
			MAXIMUM DEVIATIONS					
A	+12 30	−6 6	−0.4	+0.4	−0.8	+0.7	−1.1	−2.6
B	+4 36	+12 18	−1.5	+0.6	+0.4	+0.5	−1.7	−2.4
C	+12 18	+10 24	−1.6	−1.4	+1.8	−1.2	+2.0	−3.0
D	+4 18	+13 6	−1.3	−1.1	−0.6	+1.3	+1.4	−4.6
			SAMPLE, SPECIFICATIONS D 109 - 23 T AVERAGES					
A	9 42	10 12	0.0	0.5	8.3	11.5	79.7	50.5
B	12 18	9 12	0.0	0.4	5.9	12.5	80.7	48.8
C	10 54	6 54	0.0	0.0	3.9	11.9	83.9	44.0
D	12 42	10 42	0.0	0.0	6.4	12.1	81.1	48.1
			MAXIMUM DEVIATIONS					
A	+8 18	+4 48	±0.0	+0.9	+1.7	+1.8	+2.3	−4.3
B	+11 42	+9 48	±0.0	±1.0	−1.3	+1.2	+1.5	+3.6
C	+7 36	+2 6	±0.0	±0.0	+1.2	+2.4	−2.2	+2.7
D	+9 48	−4 12	±0.0	±0.0	−1.6	+2.7	±0.8	±0.9

Mr. Rhodes opinion was "there was a noticeable difference in the ease with which the distillations were conducted, the Carey-Kerr set-up being less troublesome than the regular A.S.T.M. apparatus."

DISCUSSION OF RESULTS

The present work confirms in general the previous work of the section and leads to the following observations:

Flask.—There is general agreement that the E-1 flask is equally satisfactory and a number of cooperators prefer it to the present Engler form.

Condenser.—The data do not indicate that the form of condenser has any particular influence on the results so that it would apparently be merely a matter of convenience as to which type of condenser is used.

Shield.—The form of shield used does not appear to influence results above 170° C.

Cylinders.—It would appear that very much more satisfactory results would be obtained it we would eliminate the determination of the volume by gravity and weigh the fractions in small tared Erlenmeyer flasks.

Thermometer.—There is no question regarding the thermometer itself, but at present as the method is printed, we must use an uncorrected thermometer. Mr. Anderton of the Bureau of Public Roads and the Federal Specifications Board in their specifications call for corrected thermometers as in our old method.

Previous work has shown that the difference between the corrected and uncorrected thermometer would normally not reject a material on specification, unless it was very close to the rejection limit, so that in view of the more general adoption of the use of the uncorrected thermometer reading by other committees of the Society we might well adopt it.

Procedure.—In the procedure, there is the question as to whether we should use 100 g. of oil or 100 cc. of oil. It is necessary for accurate results to weigh the oil under any conditions and it is believed that the use of 100 g. and expressing the fractions as a percentage by weight would give the greatest convenience in handling.

The rate of distillation that was used in the cooperative work appears to have been generally satisfactory and this might well be adopted, namely, 50 to 70 drops per minute.

The procedure in determining the softening point appears to have given very satisfactory results to judge from the general concordance obtained.

RECOMMENDATIONS

The section recommends for consideration as a proposed new Tentative Method of Test for Distillation of Bituminous Materials

Suitable for Road Treatment the method appended hereto.[1] This is the "Method B" as given in this report and consists essentially of the use of the E-1 flask with creosote type condenser and the thermometer bulb in the high position. This recommendation is made for the following reasons:

1. The American Wood Preservers Association, the American Railway Engineering Association and Committee D-7 on Timber of our Society have adopted the use of the E-1 flask and the creosote condenser.
2. The large amount of data that has been collected by the committee indicates that "Method B" using this apparatus will give results that are in substantial agreement with the present method.
3. The general opinion of those who have used this apparatus is that it is more convenient than the present method.
4. The adoption of the proposed apparatus will be a considerable step in securing uniformity of distillation apparatus.

Respectfully submitted on behalf of the Section on Distillation,

W. H. FULWEILER,
Chairman.

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[1] See p. 881.—ED.

APPENDIX II

REPORT OF SECTION ON ASPHALT CONTENT

The sectional committee recommends the acceptance of the proposed Tentative Method of Test for Residue of Specified Penetration appended to the report of Committee D-4[1] for publication as a tentative method of test. The term "residue of specified penetration" is used instead of "asphalt content," since, in the opinion of the committee, the former term expresses more definitely what is obtained by the method, and any procedure involving the heating of bitumens in open air is open to serious objection as a method for the determination of asphalt.

In view of the extended use of evaporation methods, and the apparent need for standardization of procedure, this method is offered. As a means of specifying the consistency of bituminous materials, requirements for limited percentages of residue are of minor importance; the chief value of a residue test lies in the examination and supplementary tests of the residue.

The apparatus required in the proposed method is similar to that described by Clemmer and Helmle,[2] the air-bath and container being adapted for a 100-g. sample and for the obtaining of sufficient residue for direct determination of penetration in the container and supplementary tests of residue as desired. The specified container may be obtained commercially, and is easily described. The air-bath also is susceptible of definite requirements.

The section has conducted tests on duplicate samples of nine materials by eight laboratories. Three methods were used generally: first, with an air-bath and a 100-g. sample; second, with an air-bath and a 50-g. sample; and third, with a sand-bath and a 50-g. sample. One laboratory also made tests with a flask heater air-bath and 100-g. sample. As the results of these tests may be of interest to the committee, they are appended hereto in Tables I and II.

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[1] See p. 889.—Ed.

[2] H. F. Clemmer and H. C. Helmle, "Use of Air Bath in Determination of Solid Residue of Road Oils at 100 Penetration," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 351 (1923).

TABLE I.—RESULTS OF COOPERATIVE TESTS ON DETERMINATION OF RESIDUE OF SPECIFIED PENETRATION.

Laboratory[1]	Air Bath, 100-g. Sample			Air Bath, 50-g. Sample			Sand Bath, 50-g. Sample			100-g. Sample		
	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility
					SAMPLE NO. 1							
No. 1	*60.8, 60.8, 60.9	90, 87, 87	59	*61.2, 61.2, 61.2	98, 88, 87	53	*61.2, 60.3, 60.1	98, 82, 81	86	....	....	....
No. 2	*62.4, 61.4	110, 80	88.5, 64	62.5, *63.1	110, 101	97+, 94	*61.6, 61.1	90, 80	91, 51.5	....	....	....
No. 3	*59.5, 60.0	100, 105	100, 96	60.5, 60.0	105, 90	87, 101	*59.5, 60.0	97, 90	90, 101	59.0, 59.0	105, 98	102, 108
No. 4	60.3	105	94	60.9	99	86	60.6	100	92	....	....	....
No. 5	62.1	115	60	61.0	115	65+	60.0	87	60	....	....	....
No. 6	64.9	102	71	64.1	97	93	65.8	96	44	....	....	....
No. 7	61.0, *61.3	94, 96	83, 84	62.0, *62.1	103, 102	85, 84	61.6, *61.8	111, 108	86, 86	....	....	....
No. 8	61.5	92	....	61.6	97	....	60.6	88	....	....	....	....
Average, all tests	61.3	97.1	....	61.6	99.4	....	61.1	93.0	....	....	....	....
Average, 8 tests	61.6	101.3	....	61.8	101.8	....	61.4	95.5	....	....	....	....
					SAMPLE NO. 2							
No. 1	84.4, *84.7, 84.5	94, 100, 98	110+	84.6, *84.8, 84.8	94, 98, 95	94	*84.6, 84.5, 84.8	96, 93, 105	102	....	....	....
No. 2	84.0, *84.2	85, 100	97+, 97+	*83.9, 83.8	90, 83	97+, 97+	82.7, *84.6	80, 85	97+, 97+	....	....	....
No. 3	*86.0, 86.0	108, 110	150, 130	*86.0, 86.0	111, 110	147, 130	*86.0, 86.0	106, 109	150, 128	86.0, 86.0	108, 109	131, 156
No. 4	83.0	90	100+	82.5	93	100+	82.4	92	100	....	....	....
No. 5	84.6	105	65+	85.0	110	65+	84.6	105	65+	....	....	....
No. 6	82.6	93	110+	82.7	93	110+	81.9	90	110+	....	....	....
No. 7	85.1, *84.8	108, 99	96, 95	*83.8, 84.4	95, 113	97, 97	*82.3, 82.3	89, 112	95, 97	....	....	....
No. 8	84.7	84	100+	84.6	86	100+	84.0	82	100+	....	....	....
Average all tests	84.5	98.0	....	84.2	97.7	....	83.9	95.7	....	....	....	....
Average 8 tests	84.3	97.4	....	84.2	97.0	....	83.8	93.1	....	....	....	....
					SAMPLE NO. 3							
No. 1	*60.7, 60.6, 60.8	88, 70, 74	4.0	61.0, *60.8, 60.7	66, 74, 66	4.0	61.3, 60.8, *60.7	116, 115, 115	5.0	....	....	....
No. 2	62.5, *62.6	85, 110	4.5, 5	59.4, *63.0	82, 117	4, 4	60.0, *61.1, 60.4	75, 110, 82	3.5, 4.2, 4	....	....	....
No. 3	*60.0, 60.0	106, 110	6, 5	*60.0, 60.0	105, 109	5, 6	60.0, *60.0	108, 104	9, 8	59.0, 59.0	96, 94	7, 7
No. 4	57.9	101	8.5	60.0	92	14	59.9	92	17	....	....	....
No. 5	63.6	100	10	60.0	105	12	62.6	92	15	....	....	....
No. 6	65.3	104	4.5	65.1	107	5	65.9	110	6	....	....	....
No. 7	59.7, *60.5	80, 92	6, 6.5	60.0, *60.4	105, 95	6, 6.5	*61.2, 60.0	107, 90	6, 6	....	....	....
No. 8	62.2	88	4.0	62.0	75	4.5	60.6	96	5.0	....	....	....
Average all tests	61.3	92.9	....	61.0	92.1	....	61.0	100.8	....	....	....	....
Average 8 tests	61.6	98.6	....	61.4	96.3	....	61.5	103.3	....	....	....	....

* An asterisk (*) indicates that the value has been used in average of 8 tests.

[1] **Laboratory** numbers represent the following investigators: No. 1, B. A. Anderton; No. 2, H. F. Clemmer; No. 3, W. H. Kershaw; No. 4, C. E. Lanning; No. 5, J. E. Myers; No. 6, W. F. Purrington; No. 7, A. S. Rea; No. 8, C. S. Reeve.

TABLE I.—RESULTS OF COOPERATIVE TESTS ON DETERMINATION OF RESIDUE OF SPECIFIED PENETRATION—*Continued.*

Laboratory	Air Bath, 100-g. Sample			Air Bath, 50-g. Sample			Sand Bath, 50-g. Sample			100-g. Sample		
	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility
SAMPLE NO. 4												
No. 1	63.3, 63.3, *63.8	86, 82, 92	69	*64.0, 63.5, 63.3	93, 87, 82	59	*63.7, 63.2, 63.3	98, 88, 93	52	....	....	....
No. 2	*64.1, 64.9	95, 95	84, 97+	64.8, *62.7	172, 80	62, 80	*63.0, 61.8, 62.2	90, 80, 80	97+, 60, 97+	62.0, 62.0	108, 104	80, 95
No. 3	*62.0, 62.0	96, 90	100, 105	62.0, *62.0	92, 94	90, 86	*62.0, 61.5	90, 86	90, 106	....	....	....
No. 4	64.0	95	100+	63.1	109	100+	62.4	92	100	....	....	....
No. 5	63.9	100	75+	63.6	110	50	62.4	100	45	....	....	....
No. 6	63.8	98	110+	62.9	91	98	63.8	95	106	....	....	....
No. 7	64.7, *65.0	105, 104	87, 86	62.4, *65.7	87, 113	81, 89	60.8, *60.0	94, 95	84, 84	....	....	....
No. 8	64.1	90	....	65.0	89	....	62.2	87	....	....	....	....
Average all tests	63.8	94.5	....	63.4	100.0	....	62.6	90.6	....	....	....	....
Average 8 tests	63.8	96.3	....	63.6	97.4	....	62.9	93.4	....	....	....	....
SAMPLE NO. 5												
No. 1	*68.2, 68.2, 68.4	89, 86, 121	110+	68.0, *68.3, 68.7	93, 95, 105	110+	68.8, *68.2	111, 106	110+	....	....	....
No. 2	67.6, *68.2	82, 87	97+, 97+	*68.9, 68.0	115, 80	97+, 97+	*68.1, 67.7	95, 94	97+, 97+	67.0, 67.0	104, 100	110, 142
No. 3	*67.0, 67.0	96, 104	200, 170	*67.0, 67.0	108, 90	140, 200	67.0, *67.0	96, 98	152, 153	....	....	....
No. 4	66.0	93	100+	67.2	97	100+	67.0	105	100	....	....	....
No. 5	69.5	115	75+	69.4	110	75+	67.4	85	75+	....	....	....
No. 6	65.0	90	110+	65.9	91	110+	65.0	90	110+	....	....	....
No. 7	*67.7, 67.9	101, 99	100+, 100+	66.9, *66.9	91, 94	100+, 100+	*67.2, 67.5	99, 102	100+, 100+	....	....	....
No. 8	68.6	91	....	68.8	95	....	67.6	96	....	....	....	....
Average all tests	67.6	96.4	....	67.7	97.2	....	67.4	98.1	....	....	....	....
Average 8 tests	67.5	95.3	....	67.8	100.6	....	67.2	96.8	....	....	....	....
SAMPLE NO. 6												
No. 1	96.1, 95.6, *96.4	92, 89, 95	110+	97.1, 97.0, *96.8	105, 103, 98	110+	96.7, 97.0, *96.5	103, 107, 97	110+	....	....	....
No. 2	95, *96.0	80, 90	97+, 97+	95.1, *95.1	82, 85	97+, 97+	*95.5, 94.8	95, 82	97+, 97+	95.5, 95.5	100, 98	142, 160
No. 3	*95.5, 95.5	90, 90	145, 155	95.5, *95.5	105, 99	120, 160	*95.5, 95.5	104, 91	160, 130	....	....	....
No. 4	95.9	95	100+	96.1	97	100+	96.4	98	100	....	....	....
No. 5	95.6	90	75+	96.0	98	75+	95.6	87	75+	....	....	....
No. 6	93.0	94	110+	92.5	89	110+	93.4	93	110+	....	....	....
No. 7	*97.0, 97.2	101, 105	100+, 100+	*97.3, 97.6	92, 114	100+, 100+	97.8, *97.4	110, 108	100+, 100+	....	....	....
No. 8	95.2	73	....	95.6	78	....	96.0	86	....	....	....	....
Average all tests	95.7	91.1	....	95.9	95.8	....	96.0	97.0	....	....	....	....
Average 8 tests	95.6	91.0	....	95.6	92.0	....	95.8	96.0	....	....	....	....

* An asterisk (*) indicates that the value has been used in average of 8 tests.

TABLE I.—RESULTS OF COOPERATIVE TESTS ON DETERMINATION OF RESIDUE OF SPECIFIED PENETRATION—*Continued.*

Laboratory	Air Bath, 100-g. Sample			Air Bath, 50-g. Sample			Sand Bath, 50-g. Sample			100-g. Sample		
	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility	Residue, per cent	Penetration	Ductility
SAMPLE NO. 7												
No. 1	*67.3, 67.8, 67.5	85, 78, 80	41	67.8, *67.9, 67.8	78, 96, 91	28.5	65.7, *65.3, 65.4	132,114, 80	67	....	....	....
No. 2	68.3, *69.5	110, 93	39, 31	68.0, *69.0	80, 112	25, 25	66.6, 65.8, *63.6	120, 80, 86	23, 52, 24	....	....	....
No. 3	62.0, *62.0	90, 96	27, 36	*63.0, 64.0	100, 110	42, 76	64.0, *64.0	80, 90	48, 52	61.0, 61.0	96, 94	30, 50
No. 4	62.4	96	72	61.6	105	66	59.3	102	91	....	....	....
No. 5	65.0	115	65+	65.0	120	65+	62.6	95	65+	....	....	....
No. 6	64.3	108	78	64.6	99	71	64.7	104	88	....	....	....
No. 7	*65.2, 65.0	96, 94	40, 40	*64.2, 64.3	105, 107	42, 41	63.8, *63.7	103, 99	42, 40	....	....	....
No. 8	66.4	95	....	66.6	82	....	64.2	83	....	....	....	....
Average all tests	65.6	95.0	....	65.7	98.8	....	64.2	97.7	....	....	....	....
Average 8 tests	65.3	98.0	....	65.2	102.4	....	63.4	96.6	....	....	....	....
SAMPLE NO. 8												
No. 1	67.2, *67.4	87, 94	110+	67.2, *67.2, 67.4	79, 79, 75	110+	*67.0, 66.4, 66.6	99, 90, 103	110+	....	....	....
No. 2	67.5, *67.8	90, 95	97+, 97+	*66.8, 66.7	93, 84	97+, 97+	*66.9, 66.8	105, 105	97+, 97+	....	....	....
No. 3	66.0, *66.0	92, 99	200, 170	*67.0, 66.5	98, 90	164, 134	67.0, *66.0	98, 100	164, 134	67.0, 66.0	108, 96	157, 200
No. 4	65.5	91	100+	65.0	99	100+	64.8	90	100	....	....	....
No. 5	67.0	100	....	67.0	115	....	66.2	100	....	....	....	....
No. 6	65.2	108	78	64.9	93	110+	64.8	90	110+	....	....	....
No. 7	65.0, *65.9	91, 96	75, 76	*67.1, 67.0	94, 92	76, 74	67.4, *68.0	111, 104	77, 78	....	....	....
No. 8	68.1	98	100+	68.4	114	100+	66.4	105	100+	....	....	....
Average all tests	66.6	95.1	....	66.8	92.7	....	66.5	100	....	....	....	....
Average 8 tests	66.6	97.6	....	66.7	98.1	....	66.3	99.1	....	....	....	....
SAMPLE NO. 9												
No. 1	78.1, 78.3, *78.2	116, 79, 106	1.5	*78.2, 78.1	93, 73	1.5	75.4, *75.6	125, 120	1.5	....	....	....
No. 2	74.0, *74.4	84, 90	1.5, 1.5	76.9, *77.2	115, 100	1, 1.	*74.1, 75.3	100, 90	1, 1.5	....	....	....
No. 3	*69.0, 69.0	96, 90	2.0, 2.0	*72.0, 71.0	102, 90	2.5, 2.5	71.0, *71.0	90, 102	2.5, 2.5	66.0, 66.0	92, 96	2.2, 2.5
No. 4	66.6	105	2	67.3	105	2	66.7	103	2	....	....	....
No. 5	....	....	....	....	....	....	....	....	....	....	....	....
No. 6	75.1	90	2.5	75.2	94	2	75.6	96	2.5	....	....	....
No. 7	65.6, *66.0	108, 102	1.5, 1.5	72.6, *73.1	91, 103	1.5, 1.5	75.0, *74.0	112, 102	2, 1.5	....	....	....
No. 8	77.2	80	2.0	76.2	86	2.2	72.2	87	....	....	....	....
Average all tests	72.6	95.5	....	74.4	95.6	....	73.3	102.5	....	....	....	....
Average 8 tests	72.4	95.6	....	74.2	97.6	....	72.7	101.4	....	....	....	....

*** An asterisk (*) indicates that the value has been used in average of 8 tests**

TABLE II.—NUMBER OF HEATINGS AND TIME REQUIRED TO REDUCE TO 100 PENETRATION.

	Laboratory[1]	Air Bath, 100-g. Sample		Air Bath, 50-g. Sample		Sand Bath, 50-g. Sample	
		Number of Heatings	Total Time, minutes	Number of Heatings	Total Time, minutes	Number of Heatings	Total Time, minutes
Sample No. 1..	No. 1	1	190	1	150	1	120
	No. 2	1	220	1	210	1	180
	No. 3	..	85	..	115	..	105
	No. 4	1	75	2	85	1	60
	No. 5	..	225	..	120	..	210
	No. 6	..	420	..	330	..	360
	No. 7	..	120	..	90	..	90
	No. 8	3	150	3	120	2	90
	Average time	..	186	..	153	..	152
Sample No. 2..	No. 1	1	115	1	100	1	70
	No. 2	1	250	1	195	1	130
	No. 3	..	90	..	90	..	90
	No. 4	1	65	1	40	1	50
	No. 5	..	180	..	150	..	90
	No. 6	..	540	..	390	..	450
	No. 7	..	95	..	70	..	70
	No. 8	2	105	2	75	1	60
	Average time	..	180	..	139	..	126
Sample No. 3..	No. 1	3	600	2	550	1	290
	No. 2	[a]	630	[a]	510	1	400
	No. 3	..	300	..	300	..	315
	No. 4	5	225	7	250	7	245
	No. 5	..	330	..	240	..	120
	No. 6	..	480	..	420	..	360
	No. 7	..	380	..	270	..	225
	No. 8	4	480	4	405	1	270
	Average time	..	428	..	368	..	276
Sample No. 4..	No. 1	2	230	2	180	2	145
	No. 2	1	210	1	225	1	150
	No. 3	..	100	..	125	..	60
	No. 4	2	75	2	60	3	75
	No. 5	..	225	..	105	..	90
	No. 6	..	420	..	390	..	330
	No. 7	..	240	..	195	..	130
	No. 8	3	165	4	105	1	75
	Average time	..	208	..	162	..	132
Sample No. 5..	No. 1	1	190	1	250	1	140
	No. 2	1	330	1	225	1	200
	No. 3	..	120	..	150	..	145
	No. 4	2	75	2	115	1	100
	No. 5	..	300	..	210	..	130
	No. 6	..	345	..	330	..	300
	No. 7	..	165	..	110	..	90
	No. 8	3	180	2	135	3	105
	Average time	..	213	..	191	..	151
Sample No. 6..	No. 1	1	105	1	70	1	50
	No. 2	1	150	1	130	1	100
	No. 3	..	120	..	70	..	45
	No. 4	2	65	2	25	1	35
	No. 5	..	180	..	60	..	45
	No. 6	..	210	..	195	..	180
	No. 7	..	60	..	60	..	50
	No. 8	1	105	1	75	1	60
	Average time	..	124	..	86	..	71

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[1] Laboratory numbers represent the following investigators: No. 1, B. A. Anderton; No. 2, H. F. Clemmer; No. 3, W. H. Kershaw; No. 4, C. E. Lanning; No. 5, J. E. Myers; No. 6, W. F. Purrington; No. 7, A. S. Rea; No. 8, C. S. Reeve.

[a] Intermittent.

TABLE II.—NUMBER OF HEATINGS AND TIME REQUIRED TO REDUCE TO 100 PENETRATION—*Continued.*

	Laboratory[1]	Air Bath, 100-g. Sample		Air Bath, 50-g. Sample		Sand Bath, 50-g. Sample	
		Number of Heatings	Total Time, minutes	Number of Heatings	Total Time, minutes	Number of Heatings	Total Time, minutes
Sample No. 7..	No. 1	10	1600	8	1350	7	990
	No. 2	[a]	1770	[a]	1500	[a]	1140
	No. 3	..	830	..	1280	..	980
	No. 4	5	750	11	840	10	725
	No. 5	..	1440	..	870	..	810
	No. 6	..	660	..	630	..	570
	No. 7	..	1230	..	795	..	795
	No. 8	9	1350	6	1185	5	945
	Average time	..	1079	..	1056	..	869
Sample No. 8..	No. 1	1	190	1	165	1	100
	No. 2	1	215	1	210	1	140
	No. 3	..	185	..	180	..	160
	No. 4	1	90	1	75	2	75
	No. 5	..	180	..	90	..	90
	No. 6	..	90	..	90	..	60
	No. 7	..	140	..	90	..	90
	No. 8	3	135	1	90	1	90
	Average time	..	153	..	124	..	101
Sample No. 9..	No. 1	13	2000	12	1750	11	1200
	No. 2	[a]	2160	[a]	1800	[a]	1500
	No. 3	..	740	..	1280	..	1100
	No. 4	4	775	7	810	4	650
	No. 5	..	...	..	...	..	...
	No. 6	..	1680	..	1440	..	1320
	No. 7	..	1620	..	815	..	795
	No. 8	7	1680	4	1320	10	1050
	Average time	..	1522	..	1316	..	1099

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[1] Laboratory numbers represent the following investigators: No. 1, B. A. Anderton; No. 2, H. F. Clemmer; No. 3, W. H. Kershaw; No. 4, C. E. Lanning: No. 5, J. E. Myers; No. 6, W. F. Purrington; No 7, A. S. Rea; No. 8, C. S. Reeve.

[a] Intermittent.

REPORT OF COMMITTEE D-5
ON
COAL AND COKE

Committee D-5 has held three meetings during the past year. It has revised the section under "Apparatus" of the method for determination of fusibility of coal ash as given in the Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 – 24). Revisions have been made of the Tentative Definitions of Terms Relating to Coke (D 121 – 24 T) and of the Tentative Definitions of Terms Relating to Coal (D 142 – 25 T). The Tentative Method of Test for Fineness of Powdered Coal (D 197 – 24 T) has been revised in regard to the sieves to be used and in regard to the method of testing by machine sieving.

A new Sub-Committee on Tolerances has been formed. This sub-committee has charge of the permissible differences to be allowed in making duplicate determinations for all methods of testing sponsored by the committee. As a result of recommendations by this sub-committee, revisions have been made in the permissible differences in duplicate determinations as given in the Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 – 24).

Sub-Committee IV on Standard Sizes has made progress in developing a method for size testing of anthracite. An outline of the method under consideration by the sub-committee is given in the report of the sub-committee appended hereto.

Sub-Committee I on Methods of Testing has special sub-committees on Screen Tests and Cubic-Foot Weights of Coal and Coke, on Coke Rumbler Tests, and on Sulfur Determination. All of these special sub-committees have made considerable progress on the problems assigned them. A special sub-committee of Sub-Committee I has been formed to investigate and report on methods of test for determining the "Coking Index" of coal.

PROPOSED REVISIONS OF EXISTING STANDARD METHODS OF TEST

Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 – 24).[1]—A new furnace especially designed for coal-ash fusion tests is now available on the market. This furnace has been thoroughly tested and found to be satisfactory. Other developments in apparatus available for coal-ash fusion tests make it desirable to revise the section under "Apparatus" of the method for determination of fusibility of coal ash. No radical changes are proposed, but the committee believes that the proposed changes are such as to bring the method up to date and will be of considerable help to anyone installing the requisite equipment for this determination. The proposed changes concern the specifications under "Apparatus" only and do not change the method of test. It is recommended that the following revisions in the standard methods be accepted for publication as tentative:

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[1] 1924 Book of A.S.T.M. Standards.

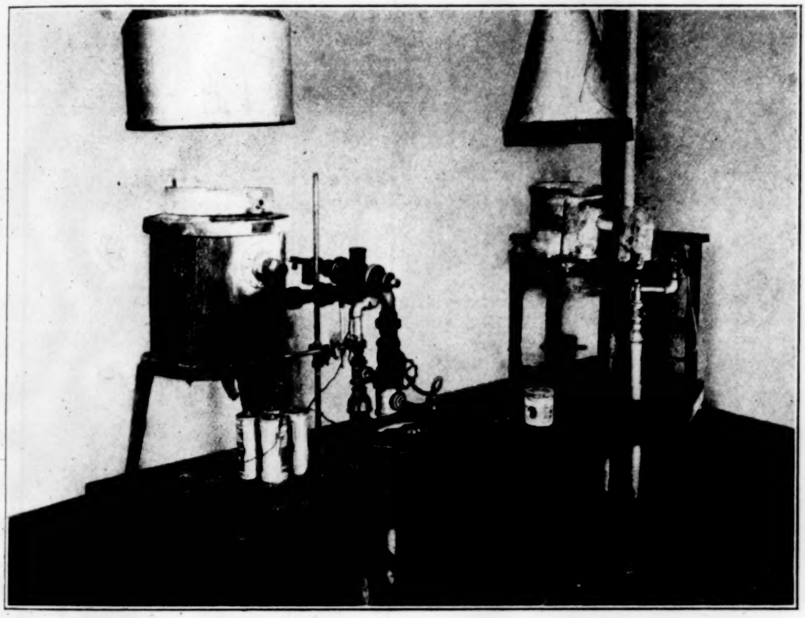

FIG. 1.—Denver Fire-Clay Furnace and No. 3 Melter's Furnace, with Accessories.

On pages 994 to 998 of the 1924 Book of A.S.T.M. Standards change the paragraphs now given under "Apparatus" to read as follows:

"*Standard Furnace.*—Gas-fired furnaces such as the coal-ash fusion furnace of the Denver Fire Clay Co., the No. 3 Melter's Furnace of the American Gas Furnace Co., or their equivalent shall be used.

"These gas-fired furnaces are especially suitable for fusion determination in that the burners are arranged on a tangent near the base of the furnace, thus producing a rotary flame which completely surrounds the crucible in which the ash cones are placed. The whirling flame heats the crucible uniformly and when the furnaces are operated with an excess of gas over air, a reducing atmosphere is maintained in the crucible, which condition gives the lowest point at which the ash fuses. Either natural or artificial gas may be used. Air should be supplied at uniform pressure.

"The stock design of the No. 3 Melter's Furnace should be modified by providing the upper cylinder with two holes in the side; a 2-in. observation hole with its center 4 in. from the top of the cylinder (excluding cover plate), and a 1-in. thermocouple hole 90 deg. to the right of the observation hole; the bottoms of these holes being in the same horizontal plane. The coal-ash fusion furnace as furnished by the Denver Fire Clay Co. is provided with suitable observation and thermocouple holes. The interior of the furnaces are cylindrical and approximately 7 in. in diameter. Counter-balanced sheet-iron canopies connected with telescopic flues to an exhaust system are placed over the furnaces for conducting the hot gases out of the room. Two furnaces and accessories are shown in Fig. 1.

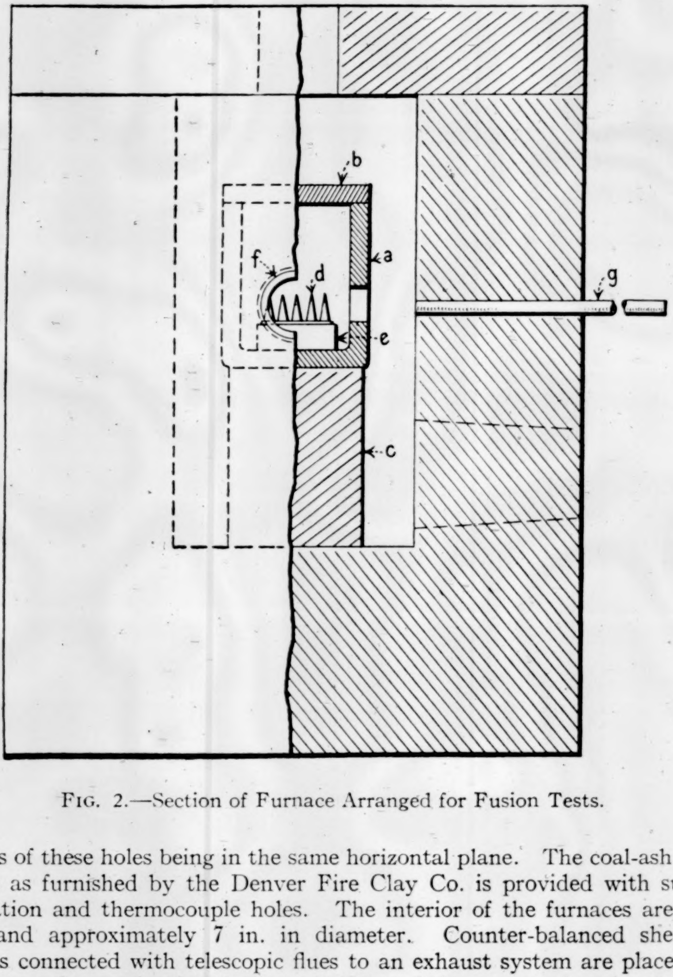

FIG. 2.—Section of Furnace Arranged for Fusion Tests.

"*Refractory Crucibles.*—The interior of the coal-ash fusion furnace as arranged for making a test is shown in Fig. 2. Crucible *a* is a Corundite crucible about 3 in. in inside diameter and about 4½ in. in height outside, with a wall thickness of about $\frac{1}{2}$ in. The crucible is provided with a cover, *b*, and should have two holes in the side, an observation hole 2 in. in diameter and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottoms of the two holes should be in the same horizontal plane. The crucible is supported by Corundite support, *c*, so that the two holes in the crucible are in line with the corresponding holes in the furnace wall. The ash cones, *d*, are supported on Corundite disk *e* so that they are visible through the observation hole of the crucible and furnace wall.

"*Observation Hole.*—A fused silica, alundum, or refractory porcelain tube, *f*, $1\frac{7}{8}$ in. in external diameter and 6 to 7 in. long, is cemented in the 2-in. observation hole of the furnace, the inner end being flush with the inside furnace wall and the other end projecting out of the furnace. A brass sleeve carrying a thin glass window is slipped on the outer end of the observation tube to prevent the escape of burning gas, which would interfere with a convenient observation of the cones. When observations at high temperatures are made, the cones are viewed through a piece of colored glass.

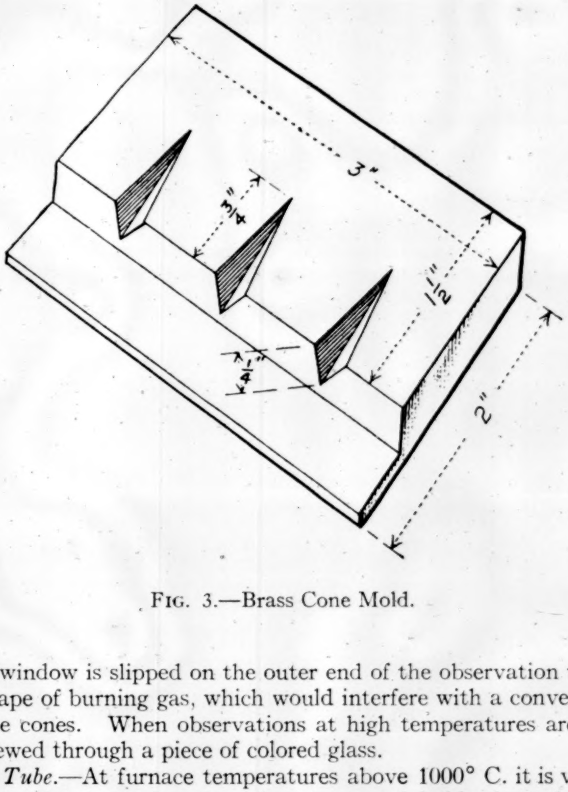

FIG. 3.—Brass Cone Mold.

"*Blowing Tube.*—At furnace temperatures above 1000° C. it is very difficult to observe the ash cones. An open refractory porcelain blowing tube, *g* (Fig. 2), about $\frac{1}{4}$ in. in inside diameter is inserted in the thermocouple hole, the inner end being flush with the inside of the furnace wall. The blowing tube is connected to the compressed air line by means of rubber tubing and the air is let into the tube at the time of observation by means of a pinchcock, thus momentarily cooling the ash cones and rendering them visible.

"*Brass Cone Mold.*—A brass cone mold for making ash cones, $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. at each side of base, which is an equilateral triangle, is illustrated in Fig. 3.

"*Pyrometer.*—Temperature measurements shall be made with a thermocouple of platinum and platinum-rhodium used in conjunction with a high-resistance millivoltmeter or potentiometer; or with an optical pyrometer of the disappearing filament type, which has been calibrated to be accurate to 10° C. up to 1400° C. and to 15° C. from 1400 to 1600° C. If a thermocouple is used it should be protected from the furnace gases by a glazed porcelain tube and so placed in the furnace that the hot junction is in the immediate vicinity of the cones. The pyrometer equipment should be checked frequently by mounting small pieces of pure gold and nickel in the same manner as the cones. With a strong reducing atmosphere, 1452° C. should be obtained for the melting point of nickel and 1063° C. for the gold. The pyrometer equipment should also be standardized from time to time through the temperature range for which it is used, by a suitably equipped standardizing laboratory, such as that of the U. S. Bureau of Standards."

There appears to be some confusion on the part of some coal chemists as to the interpretation of the permissible differences in duplicate determinations. The committee believes that these permissible differences should be more clearly stated, also that it is desirable to print all the tolerances under a special section at the end of the Standard Methods of Laboratory Sampling and Analysis of Coal instead of printing permissible differences after each method of test, as is now done. The proposed changes do not change the permissible differences now given but do state them more clearly; also new permissible differences are given in the case of determinations of carbon, hydrogen, and nitrogen. It is recommended that the following revision in the standard methods be accepted for publication as tentative:

On pages 987, 990, 993, 1000, and 1012 of the 1924 Book of A.S.T.M. Standards omit the permissible differences in duplicate determinations as given and in place thereof add the following section at the end of the standard methods:

TOLERANCES

The permissible differences between two or more determinations shall not exceed the values as specified.

A. On laboratory samples, crushed to pass through a No. 20 sieve.

	PERMISSIBLE DIFFERENCES	
	SAME LABORATORY	DIFFERENT LABORATORIES
MOISTURE:		
Under 5 per cent	0.2	0.3
Over 5 "	0.3	0.5

B. On laboratory samples, crushed to pass through a No. 60 sieve.

	PERMISSIBLE DIFFERENCES SAME LABORATORY	PERMISSIBLE DIFFERENCES DIFFERENT LABORATORIES
1. MOISTURE:		
Under 5 per cent	0.2	0.3
Over 5 "	0.3	0.5
2. ASH:		
No carbonates present	0.2	0.3
Carbonates present	0.3	0.5
Coals with more than 12 per cent of ash, containing carbonate and pyrite	0.5	1.0
3. VOLATILE MATTER:		
Bituminous coals	0.5	1.0
Lignites	1.0	2.0
4. SULFUR:		
Under 2 per cent	0.05	0.10
Over 2 "	0.10	0.20
5. ULTIMATE ANALYSIS:		
Carbon	0.3	....
Hydrogen	0.07	....
Nitrogen	0.05	....
6. CALORIMETRIC DETERMINATION:		
Permissible differences in per cent	0.3	0.5
7. FUSIBILITY OF COAL ASH:		
Permissible differences in deg. Cent.	30	50

PROPOSED REVISIONS OF TENTATIVE STANDARDS

Tentative Method of Test for Fineness of Powdered Coal (*D 197 – 24 T*).[1]—The committee has received criticisms regarding the sieves specified in this method. These criticisms are that sieves with larger openings than those specified should be included in the series, also that some of the sieves now specified could be omitted. It has also been suggested that specifications for the sieves should be given. The committee believes that these criticisms are well founded and that the tentative method be revised accordingly. It is recommended that the following revision be made in the tentative method:

Section 1.—Change from its present form: namely,

"Sieves Nos. 40, 50, 70, 100, 140, and 200 of the United States Standard Sieve Series, with close-fitting pans and covers, shall be used."

to read as follows:

"Sieves Nos. 16, 30, 50, 100, and 200 of the U. S. Standard Sieve Series, each with a close-fitting pan and cover, shall be used. Wire cloth for the sieves shall be woven (not twilled) from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder, or so made that the material will not catch. The sieve frames shall be circular, about 20 cm. (8 in.) in diameter and about 5 cm. (2 in.) or 2.5 cm. (1 in.) between the top of the frame and the cloth. The sieve openings and wire diameters shall conform to the requirements as given in Table I.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 929 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 507.

Experience has shown that the "Rapid Routine Method by Machine Sieving" can be simplified by changing somewhat the method of cleaning the sieves and weighing the residues remaining on the sieves. The committee therefore recommends that the second paragraph under "Rapid Routine Method by Machine Sieving" be changed to read as follows:

"The same sieves should be used as specified for hand sieving, and each sieve should be provided with a close-fitting pan and cover to prevent possible loss of material during sieving. A 50-g. sample of air-dried coal should be placed on each sieve (previously tared), and the sieves shaken until not more than about 0.1 g. passes through the finest sieve of the series in the machine in one minute of continuous sieving. The sieves should then be removed from the machine and the under surface of each sieve brushed clean. Sieving should then be resumed until not more than 0.1 g. passes through the finest sieve of the series in the machine in one minute of continuous sieving, when the test shall be considered finished, after which the sieves should be cleaned as before and weighed on a balance sensitive to 0.1 g. The fineness should be calculated and reported as in the hand-sieving method."

TABLE I.—REQUIREMENTS FOR SIEVE OPENINGS AND WIRE DIAMETERS WITH PERMISSIBLE VARIATIONS.

Designation		Sieve Opening		Wire Diameter		Tolerance in Average Opening, per cent	Tolerance on Wire Diameter, per cent		Tolerance in Maximum Opening, per cent
U. S. Standard Sieve Series Number	Micron Designation	mm.	in.	mm.	in.		Under	Over	
16	1190	1.19	0.0469	0.54	0.0213	±3	15	30	10
30	590	0.59	0.0232	0.33	0.0130	±5	15	30	25
50	297	0.297	0.0117	0.188	0.0074	±6	15	35	40
100	149	0.149	0.0059	0.102	0.0040	±6	15	35	40
200	74	0.074	0.0029	0.053	0.0021	±8	15	35	60

NOTE.—These sieve specifications conform to the Tentative Specifications for Sieves for Testing Purposes (Serial Designation: E 11 – 25 T), which specifications also give methods of testing the wire cloth."

Tentative Definitions of Terms Relating to Coal (*D 142 – 25 T*)[1] and *Tentative Definitions of Terms Relating to Coke* (*D 121 – 24 T*).[2]—Sub-Committee II on Nomenclature and Definitions has given careful consideration of the tentative definitions of terms relating to coal and to coke in view of criticisms from Committee E-8 on Nomenclature and Definitions, and others. The sub-committee has recommended revisions in the tentative definitions of "ultimate analysis," "moisture," "volatile matter," "fixed carbon," and "ash" of the tentative definitions of terms relating to coal. The sub-committee also has recommended revisions of the following definitions of terms relating to coke: "coke," "beehive coke," "by-product coke," "coke breeze," "moisture," "ash," "volatile matter," and "fixed carbon." Further recommendations of the sub-committee were to withdraw, pending revision, the following present definitions of terms relating to coke: "gas house coke," "beehive foundry coke," "by-product foundry coke," "beehive furnace coke," "by-product furnace coke," and "domestic coke." In order to avoid duplication in some of the definitions, it was recommended that the tentative definitions of terms relating to coke be combined with those relating to coal.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 752 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 515.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 934 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 512.

Committee D-5 has accepted the recommendations of the sub-committee and recommends that the present tentative definitions of terms relating to coal and those relating to coke be withdrawn and the revised definitions appended hereto[1] be accepted for publication as tentative.

The result of the letter ballot of the committee, which consists of 47 members, on the recommendations contained in this report is as follows:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARD			
Standard Methods of Laboratory Sampling and Analysis of Coal (D 22 - 24)	41	0	6
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Method of Test for Fineness of Powdered Coal (D 197 - 24 T)	38	0	9
Tentative Definitions of Terms Relating to Coal (D 142 - 25 T)	41	0	6
Tentative Definitions of Terms Relating to Coke (D 121 - 24 T)	38	0	9

This report has been submitted to letter ballot of the committee, which consists of 47 members, of whom 41 have voted affirmatively, none negatively, and 6 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. C. FIELDNER,
Chairman.

H. C. PORTER,
Vice-Chairman.

W. A. SELVIG,
Secretary.

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[1] See p. 903.—ED.

EDITORIAL NOTE

The proposed revision of the Standard Methods of Laboratory Sampling and Analysis of Coal were accepted for publication as tentative and appears on page 1132.

The proposed revisions of the Tentative Method of Test for Fineness of Powdered Coal were accepted. The tentative method as thus revised appears on page 898. The proposed revisions of the Tentative Definitions of Terms Relating to Coal and Tentative Definitions of Terms Relating to Coke were accepted as new Tentative Definitions of Terms Relating to Coal and Coke to replace the present tentative definitions. The tentative definitions appear on page 903.

REPORT OF SUB-COMMITTEE IV ON STANDARD SIZES

Following is an outline of a method under consideration for size testing of anthracite:

TENTATIVE SIEVE TESTING METHOD FOR ANTHRACITE

Scope.—This method of testing applies to screen tests on anthracite to determine the oversize or undersize in any given size. The size of gross sample is at variance with the A.S.T.M. Standard Method of Sampling Coal (D 21 – 16) due to the fact that the sample cannot be broken up as outlined in the standard method.

The method here outlined corresponds more nearly with present practice of routine testing in the anthracite field.

Apparatus.—The screens employed in the size testing of anthracite coal are the following:

NAME OF SIZE						
Egg	Passing	$3\frac{7}{16}$	-in. screen	Retained on	$2\frac{8}{16}$	-in. screen
Stove	"	$2\frac{8}{16}$	" "	" "	$1\frac{9}{16}$	" "
Chestnut	"	$1\frac{9}{16}$	" "	" "	$\frac{11}{16}$	" "
Pea	"	$\frac{11}{16}$	" "	" "	$\frac{8}{16}$	" "
Buckwheat	"	$\frac{8}{16}$	" "	" "	$\frac{5}{16}$	" "
Rice	"	$\frac{5}{16}$	" "	" "	$\frac{3}{16}$	" "
Barley	"	$\frac{3}{16}$	" "	" "	$\frac{3}{32}$	" "

The screens specified above shall be round-hole perforated metal plates, the holes to be staggered. The plate thickness, the center to center distances of the perforations, and tolerances of undersize and oversize will be specified at a later date after the experimental work has been completed.

Procedure.—Egg, stove and chestnut sizes shall be screened in box screens, 2 ft. by 2 ft. by 4 in., in increments of 5 lb., the screen to be shaken with a reciprocating horizontal motion at an approximate rate of 100 strokes per minute for a specified period of time.

Pea, buckwheat, rice and barley sizes shall be screened in 8-in. circular screens in some approved mechanical shaker in increments of approximately two pounds for a specified period of time. In the case of hand screening, the test may be considered complete when the undersize passing through the screen in one minute is the same in weight for two successive minutes.

Sampling (Sampling from railroad car).—The gross sample shall be 100 lb. taken from at least six places in the car about one foot below the surface.

The size of the test samples shall be as follows:

Egg, Stove and Chestnut size	25 lb.
Pea, Buckwheat, Rice and Barley size	5 lb.

Respectfully submitted on behalf of the sub-committee,

J. H. McNALLY,
Chairman.

REPORT OF COMMITTEE D-7
ON
TIMBER

During the past year, Committee D-7 on Timber has continued its investigations, looking towards the revision of the specifications for structural timbers of southern pine and Douglas fir. A number of meetings were held with the representatives of the Consulting Committee on Lumber Standards in cooperation with the U. S. Department of Commerce, and the Committee on Wooden Bridges and Trestles of the American Railway Engineering Association. As a result of this work (which has now been carried on for over three years), the committee this year submits, with the recommendation for their adoption as tentative, revisions of the existing standard and tentative standards of this Society to be published in the form of a new tentative specification. The revisions conform to the fundamental principles of strength grading advanced by the Forest Products Laboratory, Forest Service, U. S. Department of Agriculture, as a result of their research work. The report of Sub-Committee I on Specifications for Timber is appended hereto together with the proposed Tentative Specifications for Structural Joist, Planks, Beams, Stringers, and Posts.[1]

Attention should be called to the fact that the American Railway Engineering Association at its convention in March of this year adopted these specifications as standard.

Acknowledgment is made for the helpful cooperation of the members of the committees of other organizations.

Sub-Committee VI on Timber Preservatives has continued its work in cooperation with similar committees of the American Railway Engineering Association and the American Wood Preservers' Association looking to an improvement of the apparatus used in the distillation of coal-tar creosote. The report of this sub-committee is appended hereto. Appended to its report,[2] Sub-Committee VI presents a suggested revision of the present Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 18).

Consideration has been given to the following four tentative standards:

Tentative Methods of Testing Small Clear Specimens of Timber (D 143 - 24 T) and *Tentative Methods for Conducting Static Tests of*

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[1] The Tentative Specifications appear on p. 906.—ED.

[2] See p. 943.—ED.

Timber in Structural Sizes (D 198 - 24 T).—These two tentative standards are to be retained as tentative for one year, with the expectation that they will be recommended for advancement to standard next year.

Tentative Method of Test for Coke Residue of Creosote Oil (D 168 - 23 T) and *Tentative Methods of Chemical Analysis of Zinc Chloride* (D 199 - 24 T) are recommended to be retained as tentative standards in order to permit slight revision before recommending their adoption as standard next year.

Committee D-7 makes the following recommendations:

1. *Standard Specifications for Yellow-Pine Bridge and Trestle Timbers (D 10 - 15).*[1]—The withdrawal of these Standard Specifications is recommended, to be superseded by the proposed new tentative specifications.

2. *Standard Specifications for Southern Yellow-Pine Timber to be Creosoted (D 24 - 20).*[1]—The withdrawal of these Standard Specifications is recommended, to be superseded by the proposed new tentative specifications.

3. *Tentative Specifications for Structural Douglas Fir (D 23 - 20 T).*[2]—The withdrawal of these Tentative Specifications is recommended, to be superseded by the proposed new tentative specifications.

4. Publication as tentative of the proposed new Tentative Specifications for Structural Joist, Plank, Beams, Stringers and Posts.

5. *Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 24).*[1]—The withdrawal of Sections 10 to 12 covering the method of test for distillation and the substitution therefor for publication as tentative of a new Tentative Method of Test for Distillation of Creosote Oil.

These recommendations have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	**Not Voting**
1. Withdrawal of Standard Specifications for Yellow-Pine Bridge and Trestle Timbers (D 10 - 15)	21	0	0
2. Withdrawal of Standard Specifications for Southern Yellow-Pine Timber to be Creosoted (D 24 - 20)	21	0	0
3. Withdrawal of Tentative Specifications for Structural Douglas Fir (D 23 - 20 T)	20	0	1
4. Publication as tentative of Proposed Tentative Specifications for Structural Timbers	21	0	0
5. Revision of Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 24)	19	0	2

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 704 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 517.

This report has been submitted to letter ballot of the committee, which consists of 27 members, of whom 19 have voted affirmatively, none negatively and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Structural Joist, Planks, Beams, Stringers and Posts were accepted for publication as tentative to supersede, when adopted, the present Standard Specifications for Yellow-Pine Bridge and Trestle Timbers and for Southern Yellow-Pine Timber to be Creosoted. The tentative specifications appear on page 906. The withdrawal of the Tentative Specifications for Structural Douglas Fir recommended by the committee was approved.

The proposed Tentative Method of Test for Distillation of Creosote Oil was accepted for publication as tentative as a revision of the Standard Methods of Sampling and Analysis of Creosote Oil. The tentative method appears on page 943.

REPORT OF SUB-COMMITTEE I ON SPECIFICATIONS FOR TIMBER

The Society at the present time has two standard specifications for southern yellow pine structural timbers, one for timbers to be used untreated,[1] and another for southern pine timbers to be creosoted.[2] There is also a tentative specification for Douglas fir timbers.[3] These specifications were the outcome of investigations which started early in 1905. As indicated in the 1905 report of the committee:[4] "Grading as now understood consists essentially in the specification of three factors:

(*a*) A definition of standard defects and to what extent these defects shall be admitted into various grades;

(*b*) A determination of sizes, that is, length, width and thickness;

(*c*) In certain instances, the functions to which the material is to be put are to be specified."

On this basis, the present standard and tentative specifications for structural timbers were drawn. As the result of a comprehensive study of many thousand tests, the U. S. Forest Service recommended a revision of these specifications for structural timbers. This revision is based upon a better understanding as to the influence of various defects on allowable stresses for timbers, under varying conditions of use. The Forest Service suggested an approved basis for grading which consists in a closer correlation between existing defects and strength.

The sub-committee during the past three years has given serious study to these recommendations. After a detailed analysis, the general scheme employed in this basis for grading has been somewhat modified to adapt it to modern conditions of manufacture and use. Extensive revisions of the informational report published in 1925 have been made.[5] These revisions include classifying and clarifying certain paragraphs and changes in the specifications as a whole to conform with the recommendations of the Central Committee on Lumber Standards.

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[1] Standard Specifications for Yellow-Pine Bridge and Trestle Timbers (Serial Designation: D 10–15), 1924 Book of A.S.T.M. Standards.

[2] Standard Specifications for Southern Yellow-Pine Timber to be Creosoted (Serial Designation: D 24 – 20), 1924 Book of A.S.T.M. Standards.

[3] Tentative Specifications for Structural Douglas Fir (Serial Designation: D 23 – 20 T), *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 704 (1920); also 1925 Book of A.S.T.M. Tentative Standards, p. 517.

[4] *Proceedings*, Am. Soc. Testing Mats., Vol. V, p. 148 (1905).

[5] Report of Sub-Committee I on Specifications for Timber, of Committee D-7 on Timber, *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 312 (1925).

The form of presentation and details of text have been made to agree with the findings of the joint meeting of Sub-Committee I, and the Committee on Wooden Bridges and Trestles, American Railway Engineering Association, held at the U. S. Forest Products Laboratory, Madison, Wis., in September, 1925. All specification details are based upon American Lumber Standards.

These jointly-prepared specifications were submitted by the Committee on Wooden Bridges and Trestles to the American Railway Engineering Association in March, 1926, and adopted as standard.

The sub-committee herewith presents the results of its investigations in the form of specifications for structural timber and recommends their publication as tentative as appended hereto.[1] The subject has been divided into:

A. Structural grades of lumber and timbers and the method of their derivation;
B. Specifications for structural joists, plank, beams, stringers, and posts;
C. A reference code as applied to structural grades, and examples of use of code;
D. Coded specifications for structural grades.

An appendix containing notes on working stresses for Douglas fir, southern pine and other softwood structural material, together with tables of values for grades complying with the provisions for structural material as set forth in the specifications appears at the end of the specifications, as information only. This replaces the similar section in the 1925 report of the committee.

Respectfully submitted on behalf of the sub-committee,

C. E. PAUL,
Chairman.

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[1] See p. 906.—ED.

REPORT OF SUB-COMMITTEE VI ON TIMBER PRESERVATIVES

The principal work of this sub-committee during the past two years has been the advancement of the new distilling flask for creosote. Progress was reported in the reports of the committee for 1924 and 1925, and further progress is evidenced by the adoption of this flask in 1926 by the American Wood Preservers' Association and American Railway Engineering Association.

The new flask was first conceived in 1915, as an emergency substitute for the standard creosote retort, because of the scarcity, high price and variable quality of retorts then obtainable, owing to the cutting off of European supplies. American makers finally produced retorts of good quality as to material, but the variable size and shape persisted.

Many who had tried the flask were pleased with the results, and when, a few years ago, Committee E-1 on Methods of Testing undertook to attempt to unify the various distillation methods in use as described in the Standards of the Society, Committee D-7 readily agreed to take part in cooperative tests, to compare the results by its existing standard with results obtainable with the new flask. For several years, cooperative work has been carried out by this committee with other committees of the Society, notably Committee D-4 on Road and Paving Materials; and with committees of the American Wood Preservers' Association and American Railway Engineering Association.

The flask has been modified somewhat from its original form. The results have demonstrated the following advantages for the flask over the present standard retort:

1. It can be made with much greater precision as to size and shape.
2. It is preferred by analysts as neater, easier to handle and more durable.
3. Results of different operators on the same oil are more concordant with the flask than with the retort, although the average values of the results are of the same order.

Data in support of these statements have already been published in reports of the two societies mentioned; and it is considered unnecessary to duplicate these figures in this report.

The committee therefore recommends the approval of its recommendation for revising the existing Standard Methods of Sampling and Analysis of Creosote Oil (D 38 – 24)[1] as presented herewith for publication as a separate tentative standard the appended[2] proposed Tentative Method of Test for Distillation of Creosote Oil and the withdrawal of the present Sections 10 to 12 of the Standard Methods D 38 – 18, covering the distillation test.

The sub-committee further recommends that during the coming year, in cooperation with the Preservation Committee of the American Wood Preservers' Association it shall continue to study the details of the distillation test, so that any imperfection in the proposed revised method may be remedied prior to the adoption and publication of the method as standard in 1927.

Respectfully submitted on behalf of the sub-committee,

S. R. CHURCH,
Chairman.

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[1] 1924 Book of A.S.T.M. Standards.

[2] See p. 943.—ED.

REPORT OF COMMITTEE D-8

ON

BITUMINOUS WATERPROOFING AND ROOFING MATERIALS

Committee D-8 has held three meetings during the past year. As a result of intensive work of two of its sub-committees seven new specifications and one new method of test have been prepared for recommendation to the Society. Revisions have also been made in one existing standard specification, four tentative specifications and two tentative methods of test in order to harmonize them with the new material which has been prepared.

One of the outstanding accomplishments of the committee during the past year, was to bring about closer working relations between the Society and the Federal Specifications Board, Washington, D. C., the U. S. Bureau of Standards, Washington, D. C., and the Underwriters' Laboratories, Inc., Chicago. Not only has the contact between these organizations proved to be most cordial, but it has also brought about a unification in their respective specifications for roofings and waterproofing products. This will undoubtedly be welcomed by the consuming public as well as the manufacturers of these products.

The committee feels that the following tentative specifications and methods of test are ready for advancement to standard but in view of the fact that a new book of standards will not be published until 1927, will withhold its recommendations to that effect until next year.

1. Tentative Specifications for Smooth-Surfaced Asphalt Roll-Roofing (D 224 – 25 T), as revised.
2. Tentative Specifications for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 225 – 25 T), as revised.
3. Tentative Specifications for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 226 – 25 T), as revised.
4. Tentative Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 227 – 25 T), as revised.

5. Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 – 25 T), as revised.

6. Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (D 147 – 25 T).

7. Tentative Methods of Testing Smooth-Surfaced Asphalt Roll-Roofing, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 228 – 25 T), as revised.

PROPOSED REVISION OF EXISTING STANDARD SPECIFICATIONS

Standard Specifications for Primer for Use with Asphalt in Damp-Proofing and Waterproofing Below and Above Ground Level (D 41 – 25).[1] —Should the new Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings later recommended in this report be accepted by the Society, the following revision in this standard is recommended:

Section 7 (c).—Change this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "(c) Weight of Asphalt Base Present.—[The distillation method contained in Technologic Paper No. 76, Bureau of Standards, June 21, 1916, "Determination of Volatile Thinner in Oil Varnish," by E. W. Boughton.] *Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings (Serial Designation: D — - 26 T.)*"

It is recommended that this revision be incorporated in the present standard specifications without publication as tentative. The committee accordingly asks for the necessary nine-tenths vote for the adoption of this revision as standard immediately.

PROPOSED REVISION OF TENTATIVE SPECIFICATIONS AND METHODS OF TEST

NO. 1. *Tentative Specifications for Smooth-Surfaced Asphalt Roll-Roofing (D 224 – 25 T).*[2]—In order to meet criticisms received and make these specifications conform to the new ones recommended in this report, the following revisions are recommended:

Title.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "Tentative Specifications for [Smooth-Surfaced] Asphalt Roll-Roofing *Surfaced with Powdered Talc.*"

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[1] A.S.T.M. Standards Adopted in 1925.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 761 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 597.

Section 7.—Change Paragraphs (*c*), (*d*) and (*e*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"(c) Weight of Wrapping, Packing, Nails and Cement per "Square," maximum [3] *4* lb."

"(d) Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement.—

"Medium Weight, average, *not less than* 42 lb., minimum, 40 lb.

"Heavy weight, average, *not less than* 52 lb., minimum, 49 lb."

"(e) Pliability at 77° F. (25° C.).—*At least four strips out of five* shall not crack on a 10-mm. mandrel."

It is recommended that these specifications as revised be continued as tentative.

No. 2. *Tentative Specifications for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 225 - 25 T)*.[1]—For the same reasons mentioned in connection with the preceding specifications the following revisions in these specifications are recommended:

Section 7.—Change Paragraphs (*c*), (*d*) and (*e*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"(c) Weight of Wrapping and Packing Material per "Square": Slate Roll including nails and lap-cement, maximum, [3] *4* lb.

"NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weights may be increased.

Shingles (packing only), maximum 12 lb.

"(d) Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement.—Slate Roll and Shingles, average, *not less than* 82 lb., minimum, 80 lb.

"(e) Pliability at 77° F. (25° C.): Slate Roll.—*At least four strips out of five* shall not crack on 25-mm. mandrel. Shingles.—No requirements."

It is recommended that these specifications as revised be continued as tentative.

No. 3. *Tentative Specifications for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 226 - 25 T)*.[2]—In order to meet criticisms received and make these specifications conform to the new ones recommended in this report, the following revisions are recommended:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 765 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 601.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 770 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 606.

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "These specifications cover [bituminized felted fabrics] *asphalt saturated felt*, either 36 or 32 in. in width, composed of roofing felt saturated, but not coated with asphalt for use in the membrane system of waterproofing and in the construction of built-up roofs."

Section 2.—Change this section to read as follows by the addition of the italicized word and the omission of the word in brackets:

> "In the process of manufacture, a single thickness of dry roofing felt shall be [impregnated] *saturated* with an asphalt saturant."

Section 6.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The surface of the [fabric] *felt* shall not be coated or covered with talc or other substance which would tend to interfere with the adhesion between the [fabric] *felt* and the plying cement."

Section 7.—Omit Paragraph (*e*), reading as follows:

> "(*e*) *Moisture.*—Maximum, 2.5 per cent of the net weight."

Change the present Paragraphs (*f*) and (*g*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets, relettering Paragraphs (*e*) and (*f*), respectively:

> "(e) Loss on Heating [(Exclusive of Moisture)] at 105° C. (221° F.) for 5 hours.—Maximum, [2] *4* per cent."
>
> "(f) Pliability at 77° F. (25° C.).— *t least four strips out of five* shall not crack when bent [flat on itself] *though 180 deg. over a* $\frac{1}{16}$*-in. mandrel.*

Section 8.—Change Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "(a) Weight of Moisture-Free Desaturated Felt.—[The average "Number" (expressed on the basis of pounds per 480 sq. ft.) shall be 27, equivalent to 5.625 lb. per 100 sq. ft., with a permissible variation of 10 per cent.] *Minimum 5.2 lb. per 100 sq. ft. ("Number" 25).*"

Omit Paragraph (*b*), reading as follows, relettering the subsequent paragraph accordingly:

> "(*b*) Average Thickness of Desaturated Felt.—Minimum 0.025 in."

It is recommended that these specifications as revised be continued as tentative.

No. 4. *Tentative Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs* (D 227 –

25 T).[1]—For the same reasons mentioned in connection with the preceding specifications, the following revisions are recommended:

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "These specifications cover [bituminized felted fabrics] *coal-tar saturated felt* either 36 or 32 in. in width, composed of roofing felt saturated, but not coated, with refined coal tar, for use in the membrane system of waterproofing and in the construction of built-up roofs."

Section 2.—Change this section to read as follows by the addition of the italicized word and the omission of the word in brackets:

> "In the process of manufacture, a single thickness of dry roofing felt shall be [impregnated] *saturated* with a coal-tar saturant."

Section 6.—Change this section to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The surface of the [fabric] *felt* shall not be coated or covered with talc or other substance which would tend to interfere with the adhesion between the [fabric] *felt* and the plying cement."

Section 7 (g).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "(g) Pliability at 77° F. (25° C.).—*At least four strips out of five* shall not crack when bent [flat on itself] *through 180 deg. over a $\frac{1}{16}$-in. mandrel.*"

Section 8.—Change Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "(a) Weight of Moisture-Free Desaturated Felt.—[The average "Number" (expressed on the basis of pounds per 480 sq. ft.) shall be 27, equivalent to 5.625 lb. per 100 sq. ft., with a permissible variation of 10 per cent.] *Minimum 5.2 lb. per 100 sq. ft.* (*"Number" 25*)."

Omit Paragraph (*b*), reading as follows, relettering the subsequent paragraph accordingly:

> "(*b*) Average Thickness of Desaturated Felt.—Minimum, 0.025 in."

It is recommended that these specifications as revised be continued as tentative.

No. 5. *Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 - 25 T).*[2]—In order to make them more explicit and harmonize them with proposed tentative specifications, the following revisions of these methods are recommended:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 773 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 609.

[2] *Proceedings*, Am. Soc, Testing Mats., Vol. 25, Part I, p. 776 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 612.

Section 2.—Change the first paragraph to read as follows by the addition of the italicized words. Also substitute the following simplified table for the existing table:

> "From each shipment or portion thereof representing a product of the same kind, class and weight, a number of rolls shall be selected at random, equivalent to *one-half* the cube root of the total number of rolls in the lot, *except that in lots of 1000 or less, 5 rolls shall be taken.* If the cube root, as calculated, proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED	PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED
Up to 1000	5	5833 to 8000	10
1001 to 1728	6	8001 to 10648	11
1729 to 2744	7	10649 to 13842	12
2745 to 4096	8	13843 to 17576	13
4097 to 5832	9	17577 to 21952	14"

Section 3.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "The width of each roll taken shall be measured to the nearest $\frac{1}{32}$ in. The minimum *and* maximum [and average] width so obtained shall be reported."

Section 4.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "Each roll taken shall be weighed intact to the nearest $\frac{1}{4}$ lb. and the minimum *and* maximum [and average] gross weight shall be reported."

Section 5.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "5. Each roll sampled shall be stripped. All the wrappers and packing material shall be weighed together to the nearest $\frac{1}{4}$ lb. and the average *maximum* weight *thereof per roll* shall be reported. [Each roll should be temporarily fastened with a piece of light string and handled carefully, so as not to disturb any detached surfacing material.]"

Section 6.—Omit this section, reading as follows:

> "6. The minimum, maximum and average net weight per roll shall be calculated by subtracting the average weight of the wrapping and packing material as determined in Section 5 from the average gross weight as determined in Section 4."

Substitute therefor the following two new Sections 6 and 7, renumbering the subsequent sections accordingly:

"6. *Area per Roll.*—Each roll shall be unwound, observing the workmanship and finish while so doing. The length and width of each roll shall thereupon be measured to the nearest $\frac{1}{4}$ in. and the square feet of material contained in each roll calculated."

"7. *Net Weight per Roll.*—The rolls shall be rewound, fastened with pieces of light string and then each roll shall be weighed to the nearest $\frac{1}{4}$ lb. In the case of felted fabrics, calculate the weight of each roll in pounds per 100 sq. ft. and report the maximum and minimum, likewise recording the average for the rolls sampled, which shall be regarded as the corresponding weights of the entire shipment. In the case of woven fabrics, calculate the weight of each roll in ounces per square yard, and report the minimum, likewise recording the average for the rolls sampled, which shall be regarded as the corresponding weights of the entire shipment."

Section 7.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"*8. From the rolls examined, select the one whose weight per unit area is nearest the average weight per unit area of the lot.* [Each roll sampled] *The roll so selected* shall be laid flat, the first convolution or two carefully unwound, and with a knife and straight edge the sheet shall be cleanly cut across at right angles to the edges. A section measuring 30 in. in the direction of the roll's length shall be removed. If the material is surfaced with sand or other fine material any detached particles belonging to each 30-in. section shall be retained. The width of each section shall be measured to the nearest $\frac{1}{32}$ in. Each section together with any detached surfacing shall be weighed to the nearest gram. The weight in pounds per 100 sq. ft. or the weight in ounces per square yard shall be calculated from the formulas:

$$\text{Pounds per 100 sq. ft.} = 1.0582 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

$$\text{Ounces per square yard} = 1.5238 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

[From the results obtained for each roll sampled, the minimum, maximum and average weight shall be calculated] *This must check within 1 per cent of the average weight per unit area of the shipment (Section 6). If the sample fails to do this, then additional samples shall be cut from the same roll, until one is obtained which does, which sample shall be kept for further examination.*

"NOTE.—As a referee method or in case any dispute arises regarding the [weight "per unit area," the method described in Section 8 shall be followed. From the net weight of each roll determined as in Section 6, the weight per unit area may be calculated as a check,] *properties as may be ascertained from the particular sample selected, a 30-in. sample shall be taken and examined separately from each roll sampled in Section 2.*"

Section 8.—Omit this section, reading as follows, as the subject matter is covered in the new Section 7 mentioned above:

"8. The average area per roll in square feet shall be calculated by dividing the average net weight per roll, as determined in Section 6, by the average weight in pounds per 100 sq. ft. as determined in Section 7, and multiplying by 100."

"NOTE.—As a referee method or in case any dispute arises regarding the "area per roll" as calculated, each roll sampled shall be unwound and the total length measured within $\frac{1}{4}$ in. with a steel tape. From the width of each roll, as determined in Section 3, the "area per roll" may be accurately calculated as a check and the minimum, maximum and average for the shipment calculated."

Section 12.—Change the fifth sentence of Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"The tension shall be increased [at a uniform speed of 3 lb. per second using a metronome.] *by causing the lower clamp of the machine to travel at a uniform speed of 12 in. per minute.*"

Section 13.—Change items (8), (9), and (10) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"(8) Cracks when bent through 180 deg. [flat on itself] *over a $\frac{1}{16}$-in. (1.588 mm.) mandrel.*"

"(9) May be bent through 180 deg. [flat on itself] *over a $\frac{1}{16}$-in. (1.588 mm.) mandrel* in one direction without cracking, but will crack when bent through 360 deg. in the opposite direction."

"(10) May be bent through 180 deg. [flat on itself] *over a $\frac{1}{16}$-in. (1.588 mm.) mandrel* in one direction and then through 360 deg. [flat on itself] *over a $\frac{1}{16}$-in. (1.588 mm.) mandrel* in the opposite direction without cracking."

Section 15.—Add an italics side heading to read as follows:

"*Asphalt Saturated Products Only.*—"

Omit the designations "(*c*)" and "(*d*)" from the paragraphs so designated.

Section 16.—Change the second sentence to read as follows by the addition of the italicized words, with footnote, and the omission of the words in brackets:

"Each strip shall be extracted with [c. p. benzol] *carbon disulfide*[a] in an extractor described in Section 4 of the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (Serial Designation: D 147 - 25 T) of the American Society for Testing Materials."

"[a] *In this test, chloroform may be used as an equivalent solvent.*"

Section 23.—Omit the present Section 23 dealing with the fibers present.

It is recommended that the methods as revised be continued as tentative.

No. 6. *Tentative Methods of Testing Smooth-Surfaced Asphalt Roll-Roofing, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 228 - 25 T).*[1]—In order to make them more explicit and harmonize them with proposed tentative specifications, the following revisions of these methods are recommended:

Title.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

> "Tentative Methods of Testing [Smooth-Surfaced] Asphalt Roll-Roofing *Surfaced with Fine or Granular Talc,* Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles."

Section 5.—Change this section to read as follows by the addition of the italicized words:

> "The length and width of each roll shall be measured to the nearest $\frac{1}{4}$ in., and the square feet of material contained in each roll calculated. *From this, the average area of the rolls examined shall be calculated.*"

Section 8.—Change the first sentence to read as follows by the addition of the italicized words:

> "From the rolls examined, the one whose weight *per 108 sq. ft.* is nearest the average weight of the lot shall be selected."

Section 18.—Change the third sentence to read as follows by the omission of the words in brackets and the addition of a footnote as given in italics:

> "It shall be extracted with [benzol, chloroform, carbon tetrachloride or] carbon disulfide,[a] in a suitable extractor and the extraction continued until the drippings have become colorless."
>
> "[a] *In this test, chloroform may be used as an equivalent solvent.*"

Also substitute the words "carbon disulfide" for the word "benzol" in the sixth sentence.

Section 20.—Letter the present paragraph (*a*), substitute the words "carbon disulfide" for the word "benzol" in the fourth and fifth lines and add the following new Paragraph (*b*):

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[1] *Proceedings,* Am. Soc. Testing Mats., Vol. 25, Part I, p. 792 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 628.

"(*b*) For asphalt roll-roofing surfaced with granular talc, the mineral matter recovered as described in Paragraph (*a*) shall be washed through a 65-mesh copper wire screen with three washings of water of 100 cc. each. The total aqueous suspension of mineral matter which passes through the screen shall then be filtered through a weighed gooch crucible. It shall then be dried at 225° F. (107° C.) and reweighed. The difference in weight represents the mineral matter passing a 65-mesh screen which shall be converted into pounds per 108 sq. ft."

It is recommended that these methods as revised be continued as tentative.

NEW SPECIFICATIONS AND METHODS OF TEST SUBMITTED AS TENTATIVE

The committee recommends for publication as tentative the following specifications and methods of test appended hereto[1]:

1. Tentative Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc;

2. Tentative Specifications for Heavy Weight Slate-Surfaced Asphalt Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles;

3. Tentative Specifications for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs;

4. Tentative Specifications for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel;

5. Tentative Specifications for High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel;

6. Tentative Specifications for Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application for Damp-Proofing Masonry Structures;

7. Tentative Specifications for Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-Proofing Masonry Structures;

8. Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings.

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[1] See pp. 957–965, 972–982 and 998.—ED.

The results of the letter ballot of the committee upon the recommendations made in this report are as follows:

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF EXISTING STANDARD			
Standard Specifications for Primer for Use with Asphalt in Damp-proofing and Waterproofing Below and Above Ground Level (D 41 - 25)	34	0	16
II. PROPOSED REVISION OF TENTATIVE SPECIFICATIONS AND METHODS OF TEST			
Tentative Specifications for Smooth-Surfaced Asphalt Roll-Roofing (D 224 - 25 T)	30	0	20
Tentative Specifications for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 225 - 25 T)	29	0	21
Tentative Specifications for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 226 - 25 T)	29	0	21
Tentative Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (D 227 - 25 T)	28	1	21
Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (D 146 - 25 T)	32	0	18
Tentative Methods of Testing Smooth-Surfaced Asphalt Roll-Roofing, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (D 228 - 25 T)	31	0	19
III. PROPOSED NEW TENTATIVE STANDARDS			
Tentative Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc	30	0	20
Tentative Specifications for Heavy Weight Slate-Surfaced Asphalt, Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles	31	0	19
Tentative Specifications for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs	27	1	22
Tentative Specifications for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel	24	1	25
Tentative Specifications for High Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel	26	1	23
Tentative Specifications for Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application for Damp-Proofing Masonry Structures	24	1	25
Tentative Specifications for Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle for Cold Application, for Damp-Proofing Masonry Structures	22	3	25
Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings	29	2	19

This report has been submitted to letter ballot of the committee, which consists of 50 members, of whom 27 have voted affirmatively, 1 negatively, and 22 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. T. WAGNER,
Chairman.

PRÉVOST HUBBARD,
Secretary.

EDITORIAL NOTE

The proposed revisions of the Standard Specifications for Primer for Use with Asphalt in Damp-Proofing and Waterproofing Below and Above Ground Level were approved at the annual meeting by a nine-tenths vote and were subsequently adopted by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed revisions of the Tentative Specifications for Smooth-Surfaced Asphalt Roll-Roofing; for Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles; for Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs; for Coal-Tar Saturated

Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs; and of the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing; and of Testing Smooth-Surfaced Asphalt Roll-Roofing, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles were accepted. The tentative Specifications as thus revised appear on pages 948 to 956, 966 to 971, and 983 to 997.

The proposed Tentative Specifications for Asphalt Roll-Roofing Surfaced with Granular Talc; for Heavy Weight Slate-Surfaced Asphalt Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles; for Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs; for High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel; for High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel; for Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application for Damp-Proofing Masonry Structures; for Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle for Cold Application, for Damp-Proofing Masonry Structures; and the proposed Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings were accepted for publication as tentative and appear on pages 957 to 965, 972 to 982 and 998.

REPORT OF COMMITTEE D-9

ON

ELECTRICAL INSULATING MATERIALS

The committee held three meetings during the year, as follows, each for two days, in addition to the one held during this annual meeting of the Society:

At Cleveland, October 28–29, 1925;
At New York, January 21–22, 1926;
At Providence, March 18–19, 1926.

The activities of the committee continue to be devoted to the improvements of methods of testing, standardization of which it has already instituted, and the development of new methods.

EXISTING STANDARDS AND TENTATIVE STANDARDS

The committee recommends the following action with respect to the two standards and the eight tentative standards which have been adopted.

Standard Methods of Testing Molded Insulating Materials (D 48 – 24).[1]—Last year the committee recommended a number of revisions in this standard and they were accepted for publication as tentative revisions. The committee desires to add at this time one additional minor revision in connection with Fig. 1. The location of the center point of the $1\frac{3}{4}$-in. radius is not indicated and it is recommended that it be fixed $\frac{15}{16}$ in. above the bottom of the grip and $\frac{7}{8}$ in. on either side of the center line.

It is recommended that the existing tentative revisions with the addition of the above be continued as tentative.

Standard Methods of Testing Transformer and Switch Oils (D 117 – 24).[1]—The increasing attention being given to electrical insulating oils, particularly those used in transformers and high tension switches, has resulted in a wider use of this standard. The accumulated experience has indicated the desirability of more detailed instructions with regard to sampling. Furthermore, a very important demand has arisen that these methods be made applicable to oil which has been in service as well as to new oil. The committee has, therefore, entirely revised these methods and recommends that the existing

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[1] 1924 Book of A.S.T.M. Standards.

Standard Methods D 117 – 24 be withdrawn and that the proposed Tentative Methods of Testing Electrical Insulating Oils appended hereto[1] be published as a tentative standard.

Tentative Methods of Testing Insulating Varnishes (D 115 – 25 T)[2] —The committee recommended last year certain revisions of Section 3 which deals with viscosity. Additional study and discussion of this matter have indicated the desirability of further revision and it is therefore recommended that the entire Section 3, as revised last year, be replaced by the following:

> "3. The viscosity shall be determined at 20° C. (68° F.) and the results shall be stated in terms of absolute viscosity – poise[a] or centipoise (centipoise = 0.01 poise).
>
> "NOTE 1.—When measurements are made by an indirect method, the instrument used must be standardized. Oils of standard viscosity for use in standardizing such instruments can be obtained from the U. S. Bureau of Standards.
>
> "NOTE 2.—A description of the MacMichael viscosimeter as remodeled and improved for varnish testing may be obtained from the secretary of Committee D-9 together with directions for its calibration in absolute units."

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[a] The absolute viscosity of a material or its viscosity in absolute units (c.g.s., poises) has been defined as the force in dynes required to move, at a velocity of 1 cm. per second, one surface having an area of 1 sq. cm. past another parallel like surface 1 cm. away, overcoming the resistance to shear of the material filling the space between.

Where absolute viscosity is determined by means of a MacMichael viscosimeter, accurate calibration of the latter in terms of absolute units is essential and this requires careful attention to details of procedure. For that reason a rather detailed appendix of instructions has been prepared, but for the present it is proposed to make it available in the manner indicated in Note 2 rather than to print it as a part of the tentative standard.

Reports of the committee for the past two years have referred to investigations which had been made of the feasibility of substituting other materials for copper as the base of test specimens. It will be recalled that the committee reported last year that the tentative indication of the series of tests then completed was that kraft paper gave a somewhat smaller deviation in dielectric strength test results than copper and that substitution of paper for copper was being considered. The matter was deferred pending the result of a concurrent investigation of the possibility of making these tests directly on varnish films without a base. Further investigation of this proposal did not yield promising results and the committee has concluded that it is not possible to develop a practicable commercial standard using test specimens consisting of varnish films alone.

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[1] See p. 1021.—ED.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 797 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 633.

This question of a base was then taken up again. Some preliminary trials with aluminum as a base seemed to indicate an advantage for that metal and consequently a series of cooperative tests by eight laboratories on two samples of varnish were made with aluminum, copper and kraft paper, respectively, as the base. Each laboratory made the "dry" and "wet" test as prescribed by the present tentative standard on a part of the same sample of each of the two kinds of varnish with each of the three bases. The following is a summary of the results:

PERCENTAGE DEVIATION, CLEAR AIR DRYING VARNISH

	COPPER		ALUMINUM		KRAFT PAPER	
LABORATORY	DRY	WET	DRY	WET	DRY	WET
No. 1..........	9.94	8.83	18.96	14.19	5.10	10.34
No. 2..........	14.82	22.80	5.04	17.05	5.04	9.78
No. 3..........	10.10	7.72	10.10	11.03	5.15	10.10
No. 4..........	8.86	6.96	10.98	7.66	8.28	6.02
No. 5..........	9.16	15.22	7.55	10.58	6.88	5.72
No. 6..........	25.60	11.40	31.50	9.27	14.80	6.10
No. 7..........	32.30	3.00	7.82	2.96	2.29	2.06
No. 8..........	12.24	7.88	16.54	11.32	6.90	8.48
Average........	15.38	10.47	13.56	10.51	6.81	7.33

PERCENTAGE DEVIATION, BLACK BAKING VARNISH

	COPPER		ALUMINUM		KRAFT PAPER	
LABORATORY	DRY	WET	DRY	WET	DRY	WET
No. 1..........	13.60	25.10	11.78	21.40	7.05	7.68
No. 2..........	19.15	26.10	18.15	28.60	3.51	7.97
No. 3..........	13.25	20.18	14.90	18.60	8.56	8.68
No. 4..........	23.25	16.48	16.60	18.15	17.00	6.54
No. 5..........	42.00	13.24	12.17	13.28	6.22	8.67
No. 6..........	14.10	24.00	17.10	23.40	4.73	5.36
No. 7..........	10.00	5.85	9.38	15.90	6.52	8.64
No. 8..........	10.25	2.33	20.20	19.40	11.82	13.28
Average........	18.20	16.66	15.04	19.84	8.18	8.35
Grand Average.	16.79	13.57	14.30	15.18	7.50	7.84

In view of the smaller deviations in the individual tests thus established for kraft paper, and the greater consistency between laboratories, it is recommended that kraft paper be substituted for copper as the base for specimens used for dielectric strength tests by making the following changes:

Section 8.—Change Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"Specimens for the dielectric strength test shall be prepared by dipping pieces of [thoroughly cleaned, smooth sheet copper or brass] *kraft paper* about 20 cm. (7.88 in.) square and about [0.127 mm. (0.005 in.)] *0.076 mm. (0.003 in.)* thick into varnish which shall be at the consistency prescribed in Section 5 (*b*)."

"NOTE.—*The paper used shall be that which is commercially known as No. 1 Sulfate Kraft. The surface of the paper shall be smooth, free from pimples or lumps and reasonably free from hairy fibers. The paper shall also be free from conducting particles, slime spots, creases, cuts, specks or other 'paper defects.'*"

Change Paragraph (*e*) to read as follows:

"The final thickness of the specimen shall be 0.152 mm. (0.006 in.) to within ± 15 per cent."

Section 9 (*a*).—Change the words "the dielectric strength of the two films of varnish" to read "the dielectric strength of the specimen."

Section 10.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"The volts at puncture, the [net] thickness of [insulation] *the specimen* and the volts per mil of [net] thickness shall be reported for each of the ten tests, together with the average, maximum and minimum volts per mil."

"NOTE.—*This test is relative only, but it gives more uniform results than those obtained with a copper base. See the Appendix for a procedure for determining the dielectric strength on a copper base.*"

Section 12.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"The volts at puncture, the [net] thickness of the [insulation] *specimen* and the volts per mil of [net] thickness shall be reported for each of the ten tests, together with the average, maximum and minimum volts per mil."

Section 13.—Change to read as follows:

"(*a*) For the heat endurance test, specimens shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which shall be at the consistency prescribed in Section 5 (*b*).

"(*b*) The specimens shall be dipped twice as prescribed in Section 5 (*b*).

"(*c*) After removing not less than 1.27 cm. (0.5 in.) from one edge of the specimens the number of strips required by Section 14 (*a*) shall be cut from the same edge each 1.9 cm. (0.75 in.) in width."

Section 18.—Change to read as follows:

"(*a*) To test for the effect of oil, the specimens shall be prepared as prescribed in Section 13 (*a*).

"(*b*) The specimens shall be dipped and dried as prescribed in Section 8 (*b*), (*c*) and (*d*).

"(*c*) Test pieces shall be cut from the specimens as prescribed in Section 13 (*c*)."

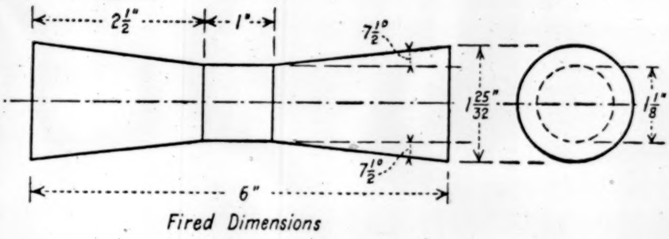
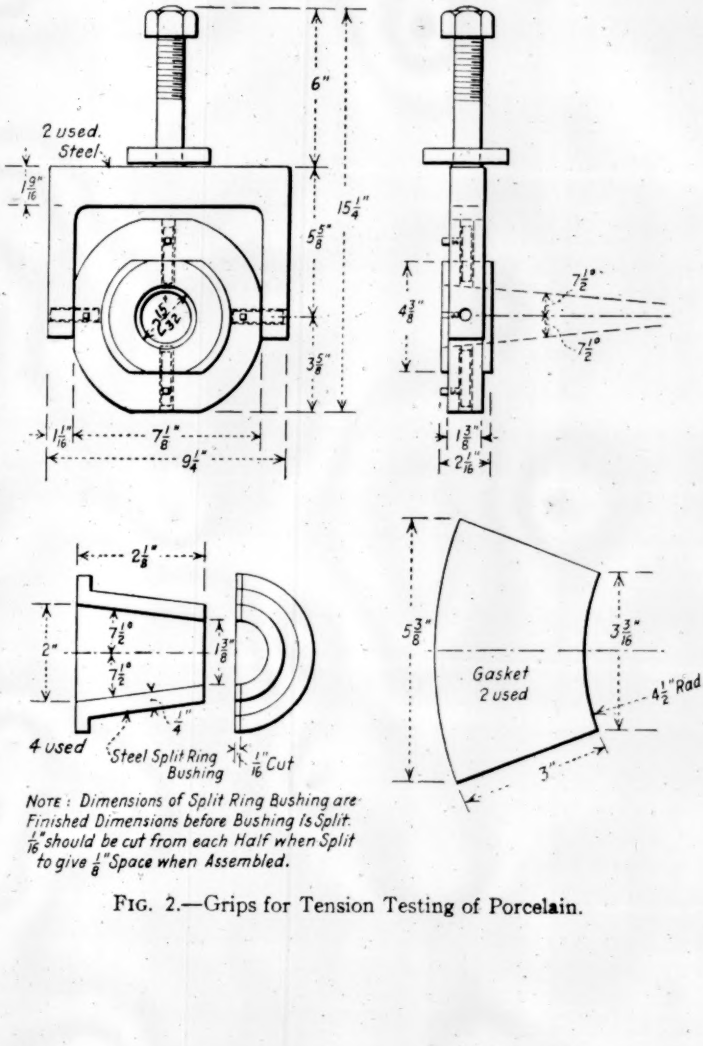

2½"
1"
7½°
1 25/32"
1⅛"
7½°
6"
Fired Dimensions

FIG. 1.—Test Specimen for Determining Tensile Strength of Porcelain.


2 used.
Steel
1 9/16"
6"
15¼"
5⅝"
2 15/32"
3⅝"
1 1/16"
7⅛"
9¼"
4⅜"
7½°
7½°
1⅜"
2 1/16"
2⅛"
2"
7½°
7½°
1⅜"
¼"
4 used
Steel Split Ring Bushing
1/16" Cut
5⅜"
3 3/16"
Gasket
2 used
4½" Rad.
3"

NOTE: Dimensions of Split Ring Bushing are Finished Dimensions before Bushing is Split. 1/16" should be cut from each Half when Split to give ⅛" Space when Assembled.

FIG. 2.—Grips for Tension Testing of Porcelain.

It is also recommended, however, that the procedure for preparing specimens with a copper base, as now prescribed, be retained as an appendix for information purposes where it is desired to obtain dielectric strength data on *films* of varnish.

The committee recommends that these tentative methods be continued as tentative as revised.

Tentative Methods of Testing Electrical Porcelain (D 116 - 24 T).[1]—It was stated in last year's report that an extensive revision of these methods was under way. The committee now recommends that the sections under sub-divisional headings "Tensile Strength" and "Compressive Strength" be withdrawn and that they be replaced by the material under the same headings as given below:

I. TENSILE STRENGTH

2. *Apparatus.*—Any standard testing machine of suitable capacity may be used providing the error in the loading range does not exceed 1 per cent.

3. *Test Specimens.*—(*a*) The test specimens for this test shall be of the form and dimensions shown in Fig. 1.

(*b*) For wet-process porcelain, the test specimens shall be made from a column obtained by forcing the batch mixture through a die. Sections of the column, after thorough drying, shall be formed to the required shape with due allowance for shrinkage. During the firing, care shall be taken to maintain the axis perfectly straight.

(*c*) For cast porcelain, the specimens shall be cast in molds of calcined gypsum (plaster of Paris) having the required shape, due allowance being made for all shrinkages. None of the material except the fins shall be removed from the specimen.

(*d*) For dry-process porcelain, the specimens shall be formed by pressure into the required shape in metal molds with due allowance for all shrinkages.

4. *Mounting of Specimens.*—(*a*) Suitable grips for holding the specimen shall be self-aligning and shall grip the specimen over sufficient area and in a manner not to cause pinching near the minimum section nor local compression at the smaller ends of the metal grips. Grips designed for the purpose and found satisfactory are shown in Fig. 2. In principle they are arranged like gimbals or a universal joint used for maintaining a mariner's compass in position. A yoke allows a ring to swing about a horizontal axis. A smaller ring is situated inside the first one but pivoted by means of pins in a plane perpendicular to the horizontal axis. The inner ring is conically shaped and holds the porcelain specimen in place with the aid of the split bushings. The two yokes are placed in the testing machine at right angles to each other.

(*b*) The test specimen shall be fitted with a compressible gasket around each conical end with the parallel edges nearly touching. Blotting paper or sheet lead $\frac{1}{32}$ in. thick has been found satisfactory. The gasket may be held in place, while assembling the test specimen in the grips, by a temporary clamp at the place of minimum section. After the specimen has been assembled in place ready for test, the temporary clamp shall be removed. The grips holding the test specimen in place in the testing machine are shown in Fig. 3. A disassembled view of the apparatus is shown in Fig. 4.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 1029 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 640.

5. *Procedure.*—(*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) The diameter of each specimen at the minimum section shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculation shall be the average of two measurements taken at right angles.

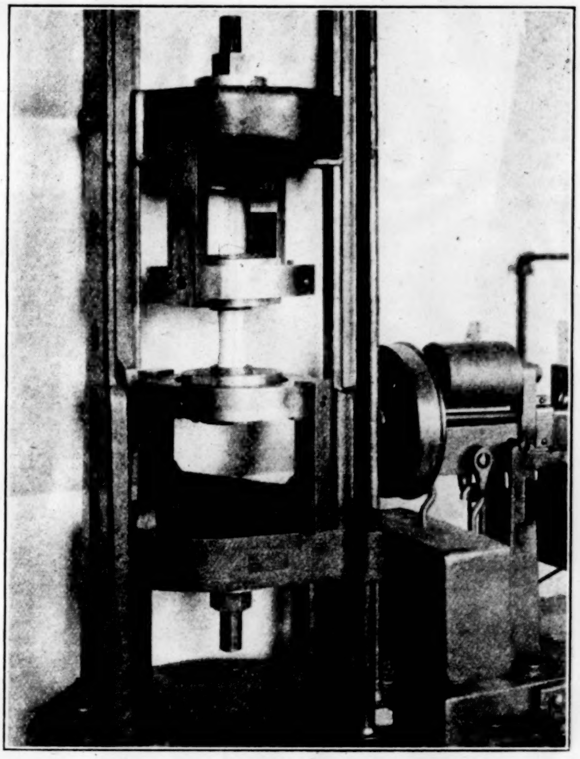


FIG. 3.—Grips and Test Specimens Assembled in Testing Machine in Tension Testing of Porcelain.

(*c*) The speed of head of the testing machine shall be such that the load can be accurately weighed.

(*d*) The tests shall be made at a temperature of about 21° C. (70° F.).

(*e*) Results on specimens which do not break in the section of minimum cross-section shall be included, though the unit stress shall be calculated using the minimum cross-section. Any results whose deviation from the mean of the deviations is more than 3 times the mean of the deviations shall be discarded.

6. *Report.*—The report shall include the following:

(*a*) The breaking load of each specimen in pounds.

(*b*) The diameter of each specimen in inches at the place of break and at the minimum section.

(*c*) The tensile strength of each specimen in pounds per square inch.

(*d*) The average of the results given in Paragraph (*c*) and the percentage average deviation from the mean.

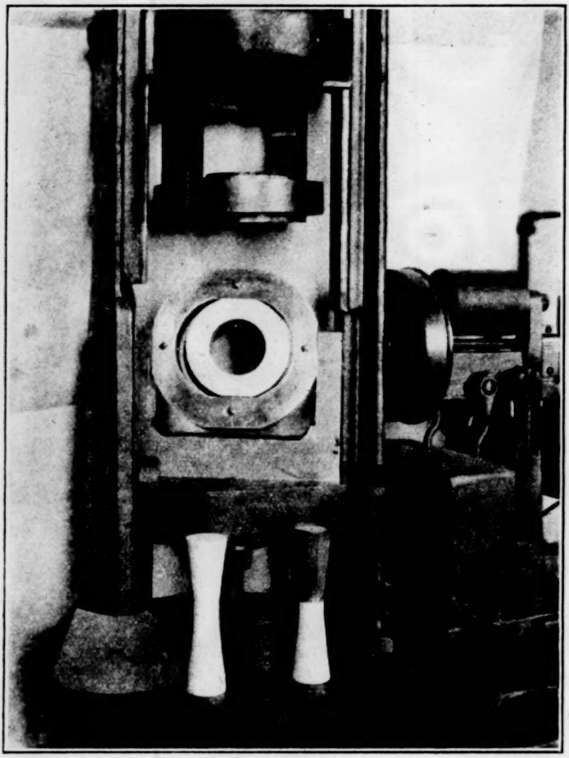


FIG. 4.—Apparatus for Tension Testing of Porcelain, Including Grips, Specimen, Split Ring and Blotting Paper Gasket.

(*e*) A description of each fracture and the behavior of the material under load. The description of the fracture should tell whether the fractured area was totally or partially rough, and whether pin holes or other flaws were found.

NOTE.—An examination of the fracture of a normal specimen will show the entire area to consist of a very coarse granular surface, indicating that the entire area was subjected to tension and that the entire surface resisted it. In a specimen containing a pin hole or other flaw, the fracture will usually start near that flaw or pass through it. Part of the surface further away from the flaw will be granular, but the surface near the flaw will be much smoother. If the specimen is compressed at a narrow portion near one of the grips, the surface is again divided into two distinct areas, the area of tension and the area of shear, the latter radiating from the spot which was most under compression.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the tensile strength in pounds per square inch of each specimen, the first value being the lowest and each succeeding one the next higher.

II. COMPRESSIVE (CRUSHING) STRENGTH

7. *Apparatus.*—Any standard testing machine of suitable capacity may be used providing the error in the loading range does not exceed 1 per cent.

8. *Test Specimens.*—(*a*) The test specimens for this test shall be in the form of cylinders and shall be 1.125 in. (2.86 cm.) in length and 1.125 in. (2.86 cm.) in diameter.

(*b*) They shall be made as described in Section 3. The flat surfaces shall be made as smooth and parallel as possible before firing. After firing, the flat surfaces shall be ground smooth and parallel.

9. *Procedure.*—(*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) A contact pad or cushion of blotting paper $\frac{1}{64}$ in. thick shall be placed between the upper and lower faces of the specimen and the self-aligning heads of the testing machine to equalize irregularities in the surfaces. Fresh cushions shall be used for each specimen.

(*c*) The diameter and length of each specimen shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculations shall be the average of two measurements taken at right angles.

(*d*) The speed of head of the testing machine shall be such that the load can be accurately weighed.

(*e*) The tests shall be made at a temperature of about 21° C. (70° F.)

10. *Initial and Ultimate Failure.*—Note shall be made of the load in pounds at initial failure but the value of the load in pounds at ultimate failure shall be determined and used in calculating the compressive (crushing) strength.

11. *Report.*—The report shall include the following:

(*a*) The load in pounds on each specimen at initial failure and the load in pounds at ultimate failure.

(*b*) The diameter and length of each specimen in inches.

(*c*) The compressive (crushing) strength of each specimen in pounds per square inch.

(*d*) The average of the results given in Paragraph (*c*) and the percentage average deviation from the mean.

(*e*) The behavior of the material under load.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the compressive strength in pounds per square inch of each specimen, the first value being the lowest and each succeeding one the next higher.

It further recommends that a new Sub-Division III, on "Transverse Strength," as given below, be added, the numbers of the succeeding sub-divisions and sections to be changed accordingly:

III. TRANSVERSE STRENGTH

12. *Apparatus.*—Any standard testing machine of suitable capacity may be used.

13. *Test Specimens.*—(*a*) The test specimens for the transverse strength test shall be in the form of cylinders and shall be 6 in. (15.2 cm.) in length and 1.125 in. (2.86 cm.) in diameter.

(*b*) They shall be made as described in Section 3.

14. *Mounting of Specimens.*—The specimen shall be supported on two steel wedge-shaped blocks with supporting edge rounded to 0.125 in. (3.175 mm.) radius. The supports shall be 5 in. (127 mm.) apart and the specimen shall be laid upon them with ½ in. (12.7 mm.) overlap at each end. The load shall be applied on top of the specimen at right angles to the specimen and midway between the supports by means of a wedge-shaped pressure piece (angle 45 deg.), the edge of which is rounded on a 0.125 in. (3.175 mm.) radius.

15. *Method.*—(*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) The diameter of each specimen shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.) The value of the diameter to be used in the calculations shall be the average of two measurements taken at right angles at the middle of the specimen.

(*c*) The load shall be applied at that constant rate of speed which will permit the beam to be kept well balanced at all loads.

(*d*) The tests shall be made at a temperature of about 21° C. (70° F.).

16. *Modulus of Rupture.*—The modulus of rupture shall be calculated for each specimen as follows:

$$M = \frac{8\ PL}{\pi\ d^3}$$

where M = modulus of rupture;
P = load in pounds at rupture;
L = distance between supports in inches;
d = diameter of specimen in inches;
π = 3.1416.

17. *Report.*—The report shall include the following:

(*a*) The breaking load of each specimen in pounds.

(*b*) The diameter and length of each specimen in inches.

(*c*) The modulus of rupture for each specimen as calculated in Section 16.

(*d*) The average of the results given in Paragraph (*a*) and the percentage average deviation from the mean.

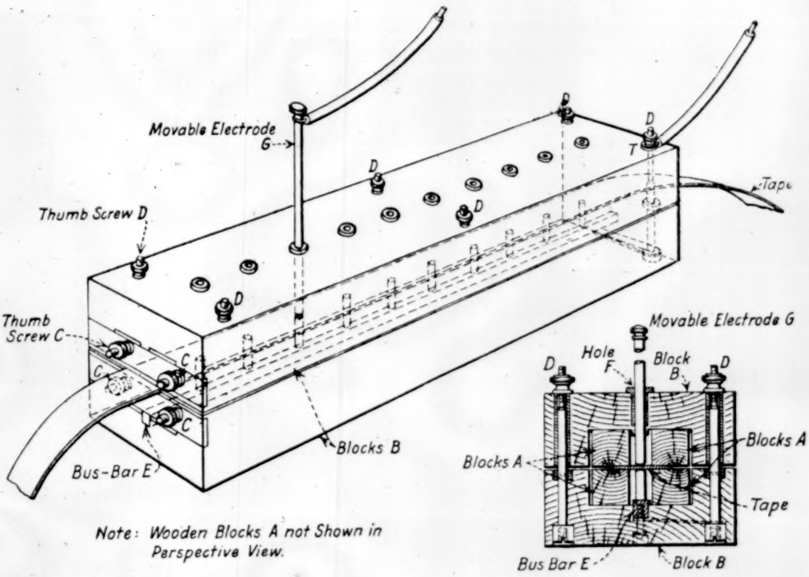
(*e*) A description of each fracture and the behavior of the material under load.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the transverse strength (modulus of rupture) for each specimen, the first value being the lowest and each succeeding one the next higher.

The procedure for the porosity test with dye as prescribed in Sections 32 to 35, inclusive, is now obsolete. Much higher pressures are now being used (4000 to 7000 lb. per sq. in.) for longer periods (3 to 12 hours), but the committee is not agreed on what would be reasonable values to incorporate in a standard. Furthermore, it considers that a procedure that will permit quantitative determinations rather than a qualitative test is preferable if a practicable procedure can be developed. Such a test, which has been developed by Mr. Louis Navias,[1] is being investigated by the sub-committee dealing with porcelain. In the meantime it is recommended that Sections 32 to 35, inclusive, be withdrawn and that the following footnote referring to the title "Water Absorption" just preceding Section 28 be inserted:



Note: Wooden Blocks A not Shown in Perspective View.

FIG. 5.—Apparatus for Dielectric Strength Test on Tape.

> "Committee D-9 is studying a method for determining quantitatively the pore volume in porcelain with the hope that it will be practicable to supersede the present dye penetration methods. (See report of Committee D-9 for 1926)."

It is recommended that these tentative methods with the above changes be continued as tentative.

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[1] "A Metal Porosimeter for Determining the Pore Volume of Highly Vitrified Ware," *Journal*, American Ceramic Society, Vol. 8, No. 12 (December, 1925).

Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 – 24 T).[1]—More extensive experience with the tape tester shown in Fig. 1 of the methods, particularly with the higher dielectric strength tapes, has shown it to be not entirely satisfactory. The principal difficulty encountered is arcing over the edge of the tape. This results not only in more time being required to get the specified ten satisfactory punctures but the charring of the wood blocks necessitates frequent renewal. Furthermore, it is highly desirable to have a form of apparatus in which the test can be made more rapidly. A new device has been developed which, it is believed, overcomes satisfactorily both of these objections.

The tape tester shown in Fig. 2 of the methods has been materially improved. It is, therefore, recommended that the present appendix be replaced by the following:

"Figure 5 shows the multiple electrode form of tape tester. In this type, a strip of tape is held between four impregnated wooden blocks, *A*, which are in turn held in place in the two main blocks, *B*, by means of the thumb screws *C* in the ends of the blocks *A*. The blocks *A* are wound butt jointed with 1-in. varnished cloth tape. The whole device is clamped tightly together by the six thumb screws *D*.

"There are ten lower electrodes which are fixed to a common bus-bar, *E*. The upper electrode, *G*, is movable and may be inserted into any of the bushed holes *F* which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus-bar *E* through the thumb-screw terminal *D* marked '*T*'. The electrodes are cylindrical brass rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).

"After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until ten punctures have been obtained.

"As more or less carbon is formed during tests, the successful operation of this device depends upon keeping the parts clean. The electrodes should be cleaned with very fine emery paper, being careful not to change their form. The blocks *A* should be rewound from time to time with new varnished cloth tape."

"Referring to Fig. 6 (*a*), the tape is held between two pieces of fiber, *A*, which, in turn, are held between two impregnated wood blocks, *B*, held in brass bases, *C*. The blocks are pressed together by a spring, *D*, which is compressed by the latch handle, *E*, through a rounded pin, *F*, fitting into a cup-shaped cap, *G*. When the handle is released, the blocks are spread apart by two light springs, *H*, mounted on the face of the lower block. The electrodes, *J*, consist of hollow rods, fitted with very light internal springs, *K*, which hold the ends against the tape during the test. Vents, *L*, relieve any gas pressure which may develop when puncture occurs.

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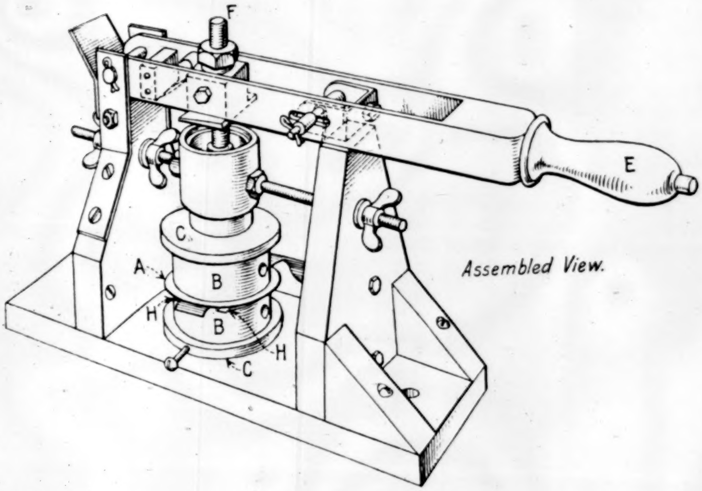
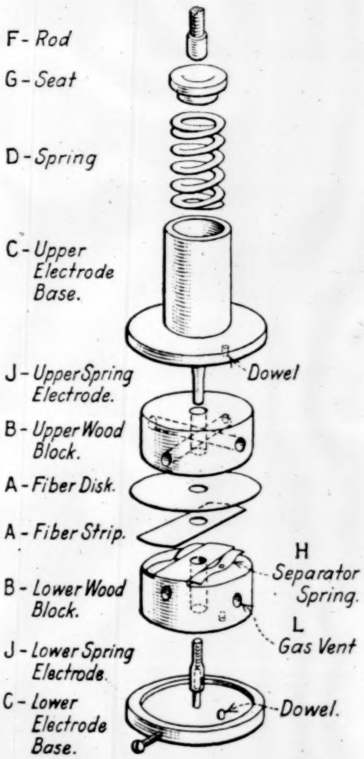
[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 1039 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 650.


F
E
C
A
B
H
B
H
C
Assembled View.

(*a*) Assembled View.


F - Rod
G - Seat
D - Spring
C - Upper Electrode Base.
J - Upper Spring Electrode.
Dowel
B - Upper Wood Block.
A - Fiber Disk.
A - Fiber Strip.
H
Separator Spring.
B - Lower Wood Block.
L
Gas Vent
J - Lower Spring Electrode.
C - Lower Electrode Base.
Dowel.

(*b*)

FIG. 6.—Lever Operated Form of Tape Tester.

"After considerable use, a leakage path will develop along the surface of one of the blocks and re-surfacing becomes necessary. This condition is avoided by using fiber disks as indicated in Fig. 6 (*b*). These disks are easily removed and replaced as necessary."

Tentative Methods of Testing Untreated Insulating Paper (D 202 - 25 T).[1]—The following minor revisions in the interest of clarity and completeness are proposed in connection with the apparatus for the measurement of thickness:

Section 8.—Change the first paragraph to read as follows by the addition of the italicized words:

"A micrometer of the spring actuated, dial type shall be used. The plunger shall be capable of being raised by the application of an upward pressure to it. The plunger surface shall be circular in shape and 12.7 mm. (0.50 in.) in diameter. *The anvil surface shall be plane and circular in shape, the diameter of which shall be not less than 12.7 mm. (0.50 in.). It shall be centered with respect to the plunger surface.*"

Omit Paragraph (*c*) reading as follows, relettering the subsequent paragraphs accordingly:

"If the instrument is provided with a device for controlling the speed of descent of the plunger, the latter shall not strike the anvil with an impact pressure greater than 1135 g. (40 oz.)."

Section 10.—Add the following paragraph to this section:

"In making measurements the plunger shall be raised to a point where its lower surface is from 0.45 to 0.55 mm. above the surface of the paper specimen lying in contact with the surface of the fixed anvil. The plunger shall be dropped from this height on the paper without retarding its speed of descent. When the thickness is read, care shall be taken not to touch the instrument."

The committee proposes that two new methods be added to this tentative standard, namely, one for "Acidity or Alkalinity" and one for "Survey for Conducting Paths." These proposed additional methods are appended hereto.[2]

The acidity test proposed is the final result of a large amount of cooperative testing. Investigation of this subject was initiated in 1923, the preliminary discussion resulting in a series of inter-laboratory tests by eleven different laboratories, using about as many different methods.

This first series of tests was completed in January, 1924, nine types of paper being tested by four different methods by the eleven laboratories. As a result of these tests, one method was found quite inadequate and the other three methods were revised in considerable detail.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 815 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 687.

[2] These methods have been incorporated, as sections 40 to 48, of the Tentative Methods of Testing Untreated Insulating Paper (Serial Designation: D 202 - 26 T), see p. 1047.—ED.

In the second series of tests the three revised methods were used on six different types of paper. The data were compiled in January, 1925, and indicated that widely varying results could be obtained by using different periods and different temperatures of extraction.

A third series of tests was undertaken with a view to obtaining detailed information in regard to these two features. The results which were compiled in April, 1925, were disappointing and indicated that other variable factors existed which were not previously appreciated. Mr. A. C. Walker, a member of a special sub-committee appointed to investigate this particular subject, presented a new method for determining acidity and a fourth series of tests was completed in October, 1925, using his method. The results of this series were promising but it was found that the samples submitted to the different laboratories were not uniform, and consequently the results obtained were not concordant. Accordingly, a fifth series of tests was undertaken with uniform samples. This series was completed in March, 1926, and most satisfactory results were obtained. The method was found to yield not only reliable and consistent results but is about the most convenient procedure available. This method, therefore, is proposed for adoption as a tentative standard. In Appendix I to this report is given a discussion of the details of this method and the reasons for the selection of the particular conditions specified.

A test for detecting conducting particles for dielectrically weak spots in untreated electrical insulating papers has been in use for several years by the General Electric Company. On first thought it would seem that this test could be performed in several different ways. However, several limitations must be imposed in order that the results may be reasonably reliable and that the apparatus may have a reasonable life. These limitations are now definitely established and they have been incorporated into a test method which will satisfactorily meet the demand which has arisen for a test to determine the dielectric uniformity of untreated paper.

The proposed test is not a test for dielectric strength of the material nor is it necessarily a test for detecting metallic particles only. The test is intended to detect also dielectrically weak spots in the paper. These weak spots may not be just on the surface but may exist within the paper. Hence the title chosen for the method. The procedure is intended to detect the number of conducting paths per unit area of paper and is therefore a measure of the dielectric uniformity of the paper.

The committee recommends that the existing tentative methods be continued as tentative with the revisions and additions herein proposed.

Tentative Methods of Testing Laminated Sheet Insulating Materials (D 229 - 25 T).[1]—It has been found that Section 16 of this tentative standard is not applicable to certain classes of materials and it is, therefore, recommended that this section, reading as follows, be deleted:

> "The deflection at the center in inches or millimeters shall be taken at a beam load corresponding to a calculated maximum fiber stress of 10,000 lb. per sq. in. (705 kg. per sq. cm.)."

In reference to the three remaining tentative standards: Tentative Method of Testing Electrical Insulating Materials for Phase Difference (Power Factor) and Dielectric Constant at Radio Frequencies (D 150 - 23 T), Tentative Method of Testing Electrical Insulating Materials for Voltage Effects at Radio Frequencies (D 175 - 25 T), and Tentative Methods of Testing Cable Splicing and Pothead Compounds (D 176 - 25 T), it is recommended that they be continued in their present status.

PROPOSED NEW TENTATIVE STANDARDS

Proposed Tentative Methods of Testing Insulating Materials for Resistance to Impact are appended to this report,[2] and it is recommended that they be accepted for publication as tentative. As impact tests are made on various classes of solid insulating materials, it is desirable to submit this method as a separate standard rather than as a part of one of the existing standards.

This procedure is recommended by the committee after an investigation by a special sub-committee extending over a period of years involving a large amount of cooperative testing with different types of machines in different laboratories. Also, machines of a more suitable size than those available on the market were specially constructed. As a result of this work, the details which affect the result have been standardized without prescribing any particular design of machine. It was desired to permit the use of any machine of either of the two types prescribed provided only that it complies with certain requirements as to details.

A *Proposed Tentative Method of Test for Surface Resistivity and Volume Resistivity of Solid Insulating Materials* is also appended to this report.[3] It is recommended that it be accepted for publication as a tentative standard. This proposed tentative standard is the result of study and investigation over a long period and will, it is hoped, fulfill a long standing demand for a standard procedure for measurements of this kind. Although insulation resistance was one of the first properties of electrical insulating materials to be measured in the early development of the electrical art, no procedure has been standardized. Unfortunately many factors affect the result and the use of many different methods and conditions in making insulation resistance tests has seriously detracted from the value of the immense amount of data which have been accumulated.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 825 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 697.

[2] See p. 1056.—ED.

[3] See p. 1059.—ED.

The proposed method is based on the experience of a number of laboratories, particularly the U. S. Bureau of Standards and the Bell Telephone Laboratories, both of which laboratories have given special attention to this particular type of measurements for many years.

MISCELLANEOUS

Insulating Varnishes:

Preliminary tests of the dielectric strength of varnish while in the liquid state gave rather unsatisfactory promise, the results being very inconsistent. However, further investigation seemed to indicate that this inconsistency was due to the condition of the electrodes and test cup. Other tests showed that fairly consistent results were obtained if the electrodes and cup were thoroughly cleaned before each "shot." A cooperative test program involving several laboratories is planned in a further investigation of this proposed test.

Molded Insulating Materials:

Additional work is being done on the proposal to substitute a disk for the cup which is now prescribed for dielectric strength tests but the investigation is not yet completed.

With the development of higher strength and more dense molded materials, it has been found that the figure-eight specimen prescribed for tension tests (Fig. 1 of Standard Methods D 48 – 24) does not always give satisfactory results. The maximum strength of the material is frequently not developed, apparently due to the influence of the accuracy of fit of the specimen in the grips and to the effect of the concentration of stress at the small area of contact between the specimen and the grips. Developmental work is being done by the committee looking to the substitution of a more satisfactory type of tension specimen.

Tentative standard methods for impact testing are proposed elsewhere in this report. A paper by Mr. W. W. Werring being presented at this annual meeting is based on experimental work done in connection with this standardization project.[1]

Sheet Insulating Materials:

The committee's work on untreated insulating papers has culminated in the proposed additional tests referred to elsewhere. Work is also being done on the development of tests for water absorption of laminated sheet materials and considerable data have been accumulated.

A reasonably complete compilation of the literature dealing with the deterioration of sheet insulating materials has been made. This will be arranged in the form of a report which will be used by the committee as a basis for the development of a standard test for deterioration.

A proposed standard method of testing sheet materials for thermal conductivity has been developed. An apparatus has been constructed and is being used by two laboratories and is being constructed by a third. A set of standard samples of various conductivities is being circulated among these laboratories. The indications are that the method will be satisfactory and that the committee will be in position to recommend it for adoption as a tentative standard next year.

To meet the demand for economy of time in making the dielectric strength test of sheet materials called for by the existing tentative procedure (Methods D 149 - 24 T), cooperative tests of certain proposals for shortening the time are now under way in eleven different laboratories on nine different materials. No data are yet available.

Liquid Insulation:

The sub-committee dealing with this subject has been very active during the past year. One result is the complete revision of the standard methods for testing transformer oils as referred to elsewhere in this report.

The matter of sludging of transformer and switch oils continues to receive a large amount of the attention of this sub-committee. This question has now become an international one because the Advisory Committee on Transformer Oils of the International Electrotechnical Commission is giving this particular matter special attention. A rather elaborate cooperative investigation between the various nations is being planned, and Committee D-9 is very closely associated with this work. This investigation will be confined to the following methods:

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[1] W. W. Werring, "Impact Testing of Insulating Materials," *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II (1926).

Swedish Method (Norline);
German Tar Method;
Swiss Method (Brown, Boverie and Co.);
U. S. Life Test.

While the committee is not yet prepared to formally recommend the Life Test described in the two previous annual reports of this committee as the most satisfactory test for sludging, it is felt that evidence so far obtained points to that conclusion. It is hoped that the further cooperative work now under way and that to be done by the International Electrotechnical Commission as mentioned above will enable Committee D-9 to arrive at a final conclusion before the next annual meeting.

TABLE I.

Items	Affirmative	Negative	Not Voting
I. PROPOSED REVISION OF STANDARDS			
Standard Methods of Testing Molded Insulating Materials (D 48 - 24)	26	0	6
Standard Methods of Testing Transformer and Switch Oils (D 117 - 24)	24	0	8
II. PROPOSED REVISIONS OF TENTATIVE STANDARDS			
Tentative Methods of Testing Insulating Varnishes (D 115 - 25 T)	21	0	11
Tentative Methods of Testing Electrical Porcelain (D 116 - 24 T)	19	0	13
Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (D 149 - 24 T)	25	0	7
Tentative Methods of Testing Untreated Insulating Paper (D 202 - 25 T)	23	1	8
Tentative Methods of Testing Laminated Sheet Insulating Materials (D 229 - 25 T)	26	0	6
III. PROPOSED NEW TENTATIVE STANDARDS			
Proposed Tentative Methods of Testing Insulating Materials for Resistance to Impact	24	0	8
Proposed Tentative Method of Test for Surface Resistivity and Volume Resistivity of Solid Insulating Materials	26	0	6

Mr. E. A. Snyder, the A.S.T.M. representative on the United States National Committee of the International Electrotechnical Commission and a member of Committee D-9, reports that at the recent meeting of the I.E.C. in this country, the Advisory Committee on Transformer Oils reached an agreement on the following:

Pour Test.—Either the British or the A.S.T.M. Method (D 97 - 25 T);
Viscosity.—To be determined in absolute units;
Flash Point.—Pensky-Martens Test (A.S.T.M. Method D 93 - 22)

Cable Splicing Compounds:

A sub-committee is working on the development of a satisfactory method for determining the viscosity of these materials over a wide range of temperatures, which usually involves a change of state from solid to very liquid. It is probable that the method ultimately recommended will involve a plastometer type of instrument.

Attention is also being given to the development of a standard method of measuring the dielectric constant and other constants of these materials and further study is being made of the specimen for dielectric strength tests.

Radio Frequency Tests:

The committee is giving considerable attention to tests of this kind with a view to improving the existing tentative methods. A series of cooperative tests for power factor and dielectric constant at radio frequencies is under way on 16 samples in several laboratories.

The result of the letter-ballot vote of the committee, which consists of 43 members, on the recommendations made in this report is shown in Table I.

This report has been submitted to letter ballot of the committee, which consists of 43 members, of whom 32 have voted affirmatively, none negatively, and 11 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. FARMER,
Chairman.

H. S. VASSAR,
Secretary.

EDITORIAL NOTE

The proposed Tentative Methods of Testing Electrical Insulating Oils were accepted for publication as tentative to supersede, when adopted, the present Standard Methods of Testing Transformer and Switch Oils. The new Tentative Methods appear on page 1021. The proposed revisions of the Standard Methods of Testing Molded Insulating Materials were accepted for publication as tentative and appear on page 1136.

The proposed revisions of the Tentative Methods of Testing Insulating Varnishes; of Testing Electrical Porcelain; of Testing Sheet and Tape Insulating Materials for Dielectric Strength; of Testing Untreated Insulating Paper; and of Testing Laminated Sheet Insulating Materials were accepted. The tentative methods as thus revised appear on pages 1002, 1010, 1029, 1037 and 1052, respectively.

The proposed Tentative Methods of Testing Insulating Materials for Resistance to Impact; and the proposed Tentative Method of Test for Surface Resistivity and Volume Resistivity of Solid Insulating Materials were accepted for publication as tentative and appear on pages 1056 and 1059, respectively.

APPENDIX I

CONTROL OF CONDITIONS IN ACIDITY DETERMINATIONS ON CABLE PAPERS AND A DISCUSSION OF TITRATION ERRORS

Cable papers with an acidity of 0.03 per cent or greater show a marked decrease in strength and increase in brittleness when baked at temperatures above 100° C., as compared with cable papers having acidities of 0.02 per cent or less. For this reason it is important to determine the acidity to 0.005 per cent. Such precision demands considerable care in the manipulation of the customary volumetric methods, and definite knowledge regarding the type and magnitude of the errors which may enter into the determination. Although colorimetric methods are now available for estimating the hydrogen-ion concentration of a solution with greater precision than any titration method, there is considerable doubt if the hydrogen-ion concentration of a solution is a reliable measure of acidity resulting from the incomplete dissociation of acid salts, such as aluminum sulfate, which are usually present.

A consideration of various methods of determining acidity in cable papers led to the conclusion that a rapid method involving extraction of the paper during disintegration by vigorous agitation for a short time in boiling water, followed by filtration and titration of the solution as near the boiling point as possible with 0.01N NaOH and phenolphthalein as indicator should prove most satisfactory.

Before it is possible to determine the effect on the percentage acidity of variations in time, temperature and rate of boiling in the extraction process, it is necessary to define carefully the conditions of titration so that the observed acidities may be properly corrected for titration errors. It is customary to correct acidity titrations by running a blank extraction on distilled water in parallel with the paper extractions. Even though this precaution is taken, significant errors may occur unless the blank correction thus obtained is correctly applied. It will be shown that if titrations are made according to a uniform procedure the errors may be calculated, rendering blank titrations unnecessary.

SOURCES OF ERROR IN TITRATING DILUTE SOLUTIONS

In titrating a water extract from paper, two sources of error, ordinarily negligible, are of significant magnitude. These errors are:

A. The Carbon Dioxide Error—due to the dissolved CO_2 present in the extract.

B. The Volume Error—due to the quantity of titer solution necessary to cause the indicator to give an end-point. The magnitude of this error depends upon the quantity of water used, its temperature at the end-point, and the nature of the indicator used.

These errors cause the titration of an acidic extract to appear high, and they must be subtracted from the observed result in order to obtain the true acidity. For alkaline extracts the converse is true.

A. *Carbon Dioxide Error:*

Discussion of Factors.—When titrating for small amounts of acidity at room temperature, the CO_2-error is a respectable fraction of the total acidity observed. It depends upon five factors, which are:

t, the temperature of the solution or extract when titrated;

V, its volume;

P, the partial pressure of CO_2 in the air of the laboratory, expressed in atmospheres;

c, the solubility of carbon dioxide in water at t; this is expressed in mols per liter when the conditions are such that the pressure of CO_2 in the air above the liquid is *1 atmosphere*. The values of c, in pure water[1] may be assumed to hold for acidity extracts, as the solubility of CO_2 in such dilute solutions is little different than in pure water;

The conditions of equilibrium between P, and the concentration of CO_2 in the solution.

We may readily dispose of the last factor. If a solution after extraction at boiling temperature is cooled rapidly to room temperature and titrated immediately, the CO_2 absorbed from the air *may* be less than that demanded by equilibrium conditions. However, this is unlikely in most cases, for equilibrium is established very rapidly; even in an unstirred liquid contained in an open beaker the process is substantially complete in about 10 minutes, as evidenced by a change in the electrical conductance of water left under such conditions.

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[1] Landolt-Bornstein Tabelln, 5th Ed. (1923), p. 768. In such tables, the solubility of a gas in water is expressed as α, being the volume of gas in liters, corrected to NTP, per liter of water. Hence c, the solubility in mols per liter, is related to α by the following equation:

$$c = \alpha/22.4$$

On the other hand, t, V, and P are rarely given sufficient consideration in titrations where small amounts of acidity are determined in large volumes of extract. It is possible to eliminate the effects of variations in t and V. However, P, the concentration of CO_2 in the air, is beyond control and is difficult to determine. The solubility c, is a function of the temperature, and is controlled only if t is controlled.

The average value of P in outdoor air is 0.00035 atmospheres, and it varies between the limits of 0.0003 and 0.0004 atmospheres. It is higher in laboratory air, mounting to 0.001, and in poorly ventilated rooms it rises to 0.0012 atmospheres. Experiments have shown that P may vary in a laboratory in a single day between values of 0.0003 and 0.0006 atmospheres, and if gas burners are in intermittent use it may reach a value of 0.001 atmospheres. The following calculations illustrate the magnitude of the CO_2-errors resulting from lack of control of the above factors.

Calculations of the Magnitude of the CO_2-Error.—In the following calculations, which illustrate the magnitude of CO_2-errors which may result from lack of control of the above factors, it is convenient to consider the conditions of titration at "room" temperature as follows:

It has been found that the volume of duplicate extractions at the end point may differ by as much as 100 cc.; also it is doubtful if "room" temperature defines the temperature of the cooled extract to better than a variation of 20° C.; and finally, P may vary between the limits of 0.0003 and 0.001 atmospheres. The combined effect of these three variables may result in large errors, particularly if the titrations are made at widely different times during the day, or one of a pair is permitted to stand over night before titrating. For example, let us consider the magnitude of the titration errors resulting from the following limiting conditions existing in two separate titrations, A and B.

CONDITIONS AT THE END POINT OF A TITRATION

	Titration A	Titration B
V	200 cc.	100 cc.
t	20° C.	40° C.
P	0.001 atmospheres	0.0003 atmospheres

The solubility c, of CO_2 in pure water is 0.0392 mols per liter at 20° C. and 0.0237 mols per liter at 40° C. The product $(P \times c)$ gives the mols of CO_2 present in a liter of distilled water at the corresponding temperature under equilibrium conditions. The amounts of CO_2 present in the above extracts are as follows:

For A ..... $P \times c = 0.001 \times 0.0392 \times 200/1000 = 7.84 \times 10^{-6}$ mols.
For B ..... $P \times c = 0.0003 \times 0.0237 \times 100/1000 = 7.11 \times 10^{-7}$ mols.

When pure water containing carbon dioxide is titrated with NaOH the following reaction is the only one of several that occurs which is pertinent to this discussion:

$$CO_2 + NaOH = NaHCO_3$$

When all of the CO_2 has been converted to sodium bicarbonate, the addition of further NaOH causes the weak acid indicator phenolphthalein to turn pink, giving an end point. Thus, if phenolphthalein is used as an indicator in titrating acidic extracts from paper, an error results in the amount of NaOH used, equivalent to that required to convert all of the CO_2 to $NaHCO_3$. It is convenient to express the CO_2 error in cubic centimeters of $0.01N$ NaOH titer solution as follows: 1 cc. of a $0.01\ N$ NaOH solution contains $0.01/1000 = 10^{-5}$ equivalents. From the above equation, 1 mol of CO_2 is equivalent to one equivalent weight of NaOH. Therefore, the CO_2-errors for the two titrations, A and B, are:

A.......$7.84 \times 10^{-6}/10^{-5} = 0.78$ cc. of 0.01 N titer solution;
B.......$7.11 \times 10^{-7}/10^{-5} = 0.07$ cc. of 0.01 N titer solution.

Thus if no blank titration is made, the maximum error may be 0.78 cc. and the minimum 0.07 cc. Even with a blank titration, a maximum error equal to the difference between A and B, or 0.71 cc. may be made.

If either t or V, or both are controlled the magnitude of the errors resulting will be less, as can be determined by making calculations similar to the illustrations given.

The magnitude of the CO_2-error decreases with increasing temperature. At 80° C., $c = 0.011$ mols per liter, and with $P = 0.001$ atmospheres and $V = 100$ cc., the maximum error under equilibrium conditions would be 0.11 cc. It is extremely doubtful if the actual absorption of CO_2 will be more than a small fraction of this amount, for if the extract is heated to boiling and then titrated before the temperature falls below 80° C., the steam rising from the surface of the solution and flowing out of the mouth of the flask no doubt effectively prevents equilibrium from being established or even approximated. Therefore the CO_2-error above 80° C. may be neglected, as may be seen from the comparison of calculated and actual volume errors in some experimental titrations discussed below.

B. Volume Error:

Water, uncontaminated by dissolved impurities, ionizes slightly. Thus, there are always present small and equal quantities of hydrogen ions, H^+, and hydroxyl ions, OH^-. At room temperature the concentrations (H^+) and (OH^-) of these ions are of the order of 10^{-7} mols per liter each. According to the principle of mass action, the product of these concentrations is a constant, and is termed the ionization constant of water, K_w, thus:

$$(H^+) \times (OH^-) = K_w$$

At 20° C., this constant has the value 5.5×10^{-15}, and from this equation the actual values of $(H^+) = (OH^-)$ may be calculated:

$$(H^+) = (OH^-) = \sqrt{5.5 \times 10^{-15}} = 0.74 \times 10^{-7} \text{ mols per liter.}$$

If it were practicable to use an indicator which registers a sharp color change as the (H^+) of a solution reaches 0.75×10^{-7}, the error in a titration for the acidity or alkalinity of paper extracts would be negligible, for only a small fraction of the total indicator present must be converted from the acid form to the alkali salt form to register the end point. For example, it has been found[1] that when 10 per cent of the total phenolphthalein present in a solution has been transformed from the colorless acid form to the sodium salt by the addition of this equivalent of alkali a pink color is readily observed. If 15 per cent is transformed a strong pink color is developed. Phenolphthalein is the most suitable indicator for many purposes, as it is a single colored indicator, but it is essential to understand the error which is involved when the end point of an acidity extract is determined with its aid.

At 20° C., phenolphthalein exhibits a 15 per cent transformation from colorless to colored in pure water when the (H^+) is reduced to 8.3×10^{-10} mols per liter, and not at the value of 0.74×10^{-7} which represents the true neutral point for water. This (H^+) at the end-point with phenolphthalein corresponds to a $(OH^-) = 6.6 \times 10^{-6}$, when substituted in the above equation for K_w. Thus, if phenolphthalein is put in pure water at 20° C., the solution remains colorless, indicating that the solution is acid with respect to this indicator. In order to indicate what we define as "neutral to phenolphthalein" alkali must be added to the water to increase (OH^-) from 0.74×10^{-7} to 6.6×10^{-6}; that is, $(6.6 \times 10^{-6} - 0.74 \times 10^{-7})$ mols of OH^- must be added to a liter of water to cause phenolphthalein to give a pink end point. The latter term may be neglected so that in dilute solutions sufficient NaOH must be added to a given volume of water to provide a concentration of 6.6×10^{-6} mols of OH^- ions per liter, and if ionization is assumed to be complete, this is equivalent to 6.6×10^{-6} mols of NaOH. When titrations are made in small volumes of solution—50 cc. or less—and the titer solution is 0.1 N or stronger, this volume error is negligible, but where 0.01 N titer solutions are used and the volume of extract mounts to 100 to 300 cc. this error may not be ignored. A simple equation by means of which the volume error (E_v) may be calculated is as follows:

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[1] A. A. Noyes, *Journal*, Am. Chemical Soc., Vol. 32, p. 825 (1910); also Rosenstein, *Journal*, Am. Chemical Soc., Vol. 34, p. 1117 (1912).

$$E_v = (V/N) \times (OH^-),$$

where

E_v = the volume error expressed in cubic centimeters of the titer solution;
V = the volume of the extract at the end point;
N = the normality of the NaOH titer solution; and
(OH^-) = the hydroxyl-ion concentration of the extract at the end point, expressed in mols per liter.

This equation simply translates the quantity of excess alkali required to produce an end point into its equivalent volume of titer solution expressed in cubic centimeters. The volume error increases with temperature in contrast to the CO_2-error which decreases with increase in temperature. The reason for this is found in the effect of temperature on the ionization constant of water and on the ionization constant of the indicator.

The ionization of water increases with temperature,[1] as follows:

Temperature (t)...	0°C.	18° C.	25° C.	50° C.	75° C.	100° C.
$K_w \times 10^{14}$........	0.089	0.46	0.82	4.5	16.9	48

while that of all solutes which ionize in water *decreases* (for example, phenolphthalein), and it is significant that the ionization of water increases much more rapidly than the ionization of solutes decreases. If the ionization of the indicator phenolphthalein decreases as rapidly with increase in temperature, as the ionization of water increases, the volume error would remain unchanged.

Phenolphthalein exhibits the following changes with temperature in the point at which the indicator is 15 per cent transformed into the pink ionized salt:[2]

Temperature....................	20° C.	50° C.	70° C.	100° C.
$(H^+) \times 10^{10}$....................	8.3	18.6	37.2	79.4

In calculating the volume error according to the equation given, it is necessary to determine (OH^-) at the end point for the indicator used. By combining the value of (H^+) determined from the transformation point of phenolphthalein at various temperatures, with corresponding values of K_w, values of (OH^-) were obtained for the end point at these temperatures. Substituting these in the equation for E_v, the curve of Fig. 1 was obtained. This curve simplifies the correction for the volume error in any titration when the temperature and volume of the solution at the end point are known.

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[1] A. A. Noyes, Carnegie Inst. Publication, Vol. 63, p. 346 (1907).

[2] These data were interpolated from a table given in: "The Determination of Hydrogen Ions," by W. M. Clarke, 2nd Ed., p. 132 (1923).

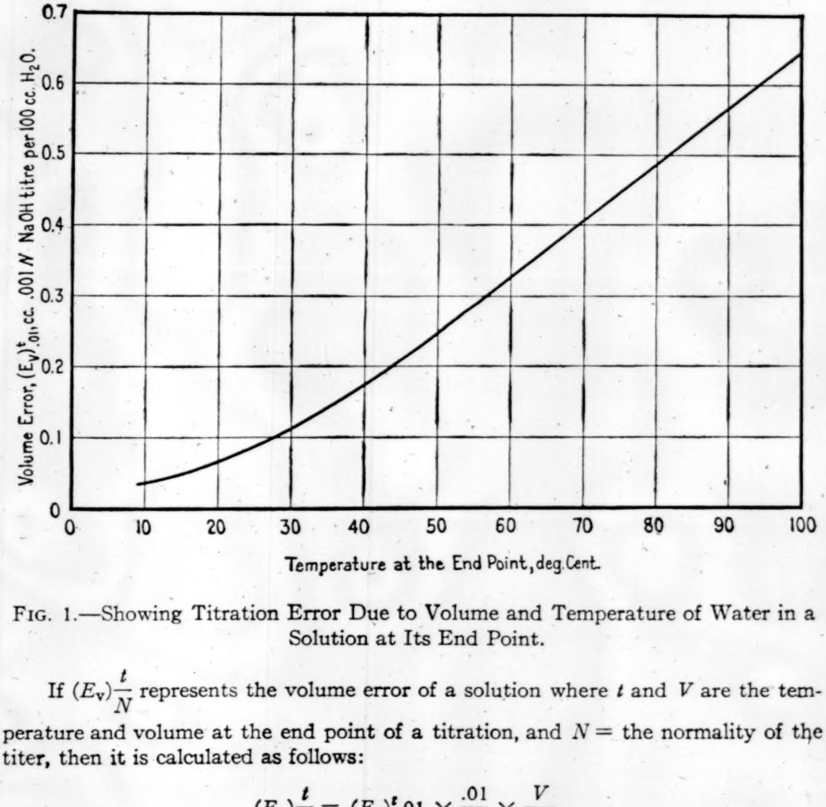


FIG. 1.—Showing Titration Error Due to Volume and Temperature of Water in a Solution at Its End Point.

If $(E_v)\frac{t}{N}$ represents the volume error of a solution where t and V are the temperature and volume at the end point of a titration, and $N =$ the normality of the titer, then it is calculated as follows:

$$(E_v)\frac{t}{N} = (E_v)^t.01 \times \frac{.01}{N} \times \frac{V}{100}$$

For example, a titration was made on 150 cc. of distilled water at 80° C. The alkali required to obtain a strong pink color with phenolphthalein was 0.69 cc. of 0.01 N NaOH. The volume error as calculated from the curve is 0.75 cc. If the CO_2-error were equal to the theoretical value of 0.17 cc. per 150 cc. of solution at this temperature, the alkali required would have been 0.92 cc. Therefore, it is evident that the CO_2-error is small at elevated temperatures. The difference between 0.75 cc. and 0.69 cc. is within the error of the titration if the end point is uncertain to 1 drop of 0.01 *N* NaOH in this volume of solution. This corresponds to ±0.05 cc., and the observed value might be $0.75 \pm 0.05 = 0.70$ or 0.80 cc.

The amount of indicator to be used in a titration of a dilute solution is important. In the experiment just described, 5 drops of a solution containing 0.5 g. of phenolphthalein in 100 cc. of alcohol was used. This indicator solution is equivalent to 0.016 *N* (by volume). If all of the indicator in the 5 drops were transformed from the colorless to the colored form, $5 \times 1.6 = 8$ drops of 0.01 *N* NaOH would be required. Inasmuch as 15 per cent transformation yields a sharp end point, only about 1 drop of the NaOH would be required to produce a sufficiently strong end point. This consideration applies up to 100 cc. of titered solution, but above this volume the subjective error in detecting color changes of the indicator increases rapidly, and it should be emphasized that all titrations are much more precise if made in as small a volume as possible.

The use of methyl orange or other two-colored indicators cannot be recommended in titrations of paper extracts, for the color change at the end point is often obscured by colored impurities extracted from the paper. The colorless-to-colored type of indicator such as phenolphthalein is much more satisfactory, but unfortunately the number of such indicators is limited.

BEST CONDITIONS FOR TITRATION

It is recommended that all titrations be made under uniform light conditions. Daylight is usually considered most desirable, but it is worthy of emphasis that due to the variability of daylight from day to day, titrations can be made far more satisfactorily if a constant source of suitable artificial light be provided. A convenient method of obtaining such a source of illumination is as follows:

Provide a wooden box approximately 2 ft. square or slightly larger. This is set on the laboratory table on one side, with the open top facing the operator. A hole is cut through the right-hand side of the box near the top, and the exterior side of this hole is faced with a piece of transite having a hole concentric with that of the box, and slightly smaller than the diameter of a bulb of a 75-watt Daylite Mazda lamp. This lamp is mounted on a ring stand so that the end of the bulb rests against the hole in the transite. The light is shielded with a plain cone reflector which permits light to pass only through the hole and illuminate the interior of the box. A hole is cut in the top of the box to admit the burette for titration. The interior of the box is lined with white unglazed paper, or painted with a flat white paint. White filter paper has been found particularly satisfactory for a lining, as it provides an ideal background against which to determine end points.

Conclusion.—If titrations are made at very nearly the boiling point of water it is possible to apply satisfactory corrections for the errors that occur, whereas if the titrations are made at room temperature the CO_2-error may not be eliminated in all cases. It has been found that the end point is easier to define in hot solutions than in cold solutions.

REPORT OF COMMITTEE D-11

ON

RUBBER PRODUCTS

Two meetings of the committee have been held during the year in addition to the one held during the annual meeting, namely, at Cleveland, October 28, 1925, and at Providence, March 17, 1926.

The committee recommends that the Society's 11 standards and 3 tentative standards dealing with rubber products be continued in the present status. It has no new tentative standards to recommend at this time.

As was indicated in its report of last year, the committee is devoting most of its attention to the subject of performance tests of rubber products. The trend in specification writing—at least for engineering products—is towards the performance type of specification rather than the material type. This is logical, for specifications should not only insure the furnishing of a product which will render the service desired, but they should interfere as little as possible with the development of improvements. When a performance test is available which will give a reliable demonstration of the suitability of material for the service intended, specifications based on such a test are preferable to those based on the usual material and construction requirements.

Existing rubber specifications are of the latter type. They prescribe the composition which is based on experience, together with certain chemical and physical tests which are designed to insure the furnishing of that composition. It has long been recognized that this kind of a specification is a makeshift, and the committee is therefore concentrating attention on the development of performance tests. The process is exceedingly slow because much testing and experimenting must be done. In many cases a machine and test procedure must be devised and in all cases a proposed test must be very thoroughly tried out by all interests involved. Three kinds of performance tests are being actively studied by the committee, namely,

1. An abrasion test, that is, a test for durability under standard abrasive conditions;

2. A flexing test for rubber belting, that is, a test to deter-

mine the life of rubber belting under standardized conditions of reversed bending and stress;

3. An aging test for all rubber products, that is, a standard test intended to show the rate of deterioration which may be expected when a rubber product is exposed to air under normal conditions.

Abrasion Tests:

A sub-committee under the chairmanship of F. G. Breyer has been very active in investigating the abrasion testing problem. After a careful analysis, the committee agreed that abrasion testing must be comparative. Accordingly it was necessary to choose and test at least two tentative compounds. The requirements for these compounds were that they should be widely different in abrasion resistance and that they should be easily duplicable. Two compounds were finally chosen which it was believed would best meet these requirements. A large batch of each of these compounds was milled on a 16 by 42-in. mill by the New Jersey Zinc Co. and cured slabs were sent to about 20 laboratories for test. Tension tests were requested in addition to abrasion tests in order to have all pertinent information available for future reference. The same laboratories were requested also to make up these same two compounds themselves and test them over a range of cures in order to obtain incidental information as to the duplicability of the compounds.

The data collected in this preliminary series of tests can be summarized briefly as follows: In the abrasion tests the average of the tests on the samples supplied by the New Jersey Zinc Co., involving 5 different methods and 15 laboratories, showed compound B to be 52 per cent higher in abrasive resistance than compound A. The average of the tests on samples made up by the individual laboratories and involving 8 methods and 13 laboratories showed compound B to be 74 per cent higher in abrasive resistance than compound A.

In the tension tests, the corresponding figures were 6.5 and 14.7 per cent, respectively, so that it is evident that tensile strength is no measure of the relative resistance to abrasion.

The conclusions indicated by these tests are about as follows:

1. The abrasion tests on slabs sent out by the committee and tested in 15 laboratories showed that one of the compounds had a greater abrasive resistance than the other in every case. This increase in abrasive resistance was in the neighborhood of 50 per cent.

2. In general, the results of the abrasion tests on the slabs sent out by the committee agreed with the abrasion tests on compounds

milled in the individual laboratories. In the latter case, however, the abrasion resistance of the compound with high abrasive resistance was relatively better than in the case of the slabs sent out by the committee.

3. The tension test data, covering the tests over a range of cures, showed very satisfactory checks, especially when it is considered that in some cases pigments of different source and origin were used. The fact that variability in testing is the most important factor in duplicating results is shown by the fact that the tests on the supposedly uniform slabs, which were sent out by the committee, were practically no better than the tests on compounds mixed in the individual factories.

The committee concludes that while these results are encouraging, the tests must be repeated with such modifications as experience has indicated. It is proposed in repeating the work that each member of the committee will make up a set of slabs for distribution to the other cooperating laboratories. It was found that some of the discrepancies in the results were due to variation in the conditions of milling and testing. Consequently, it is proposed to standardize the conditions very rigidly in the second series of tests. One of the conditions that is particularly important is that of moisture. Some preliminary unpublished results from the laboratories of the New Jersey Zinc Co. showed that exposure to relatively high humidity lowers the abrasive resistance and that a relatively low abrasion-resistance compound is affected more than high abrasion-resistance compound. This probably accounts in part for divergencies of 20 to 30 points in abrasive resistances when re-checks were attempted two months after the original tests were made. Another condition which must be controlled is the variability in milling, but it is not certain whether the differences between the laboratories were due to differences in temperatures in milling or to the use of mills of different sizes and roll speeds. The U. S. Bureau of Standards is carrying out some investigational work on this phase of the problem.

Performance Test for Rubber Belting:

A sub-committee under the chairmanship of W. L. Sturtevant is actively at work on the standardization of a performance test for rubber belting. The committee agreed on the following as the important elements in such a standard test:

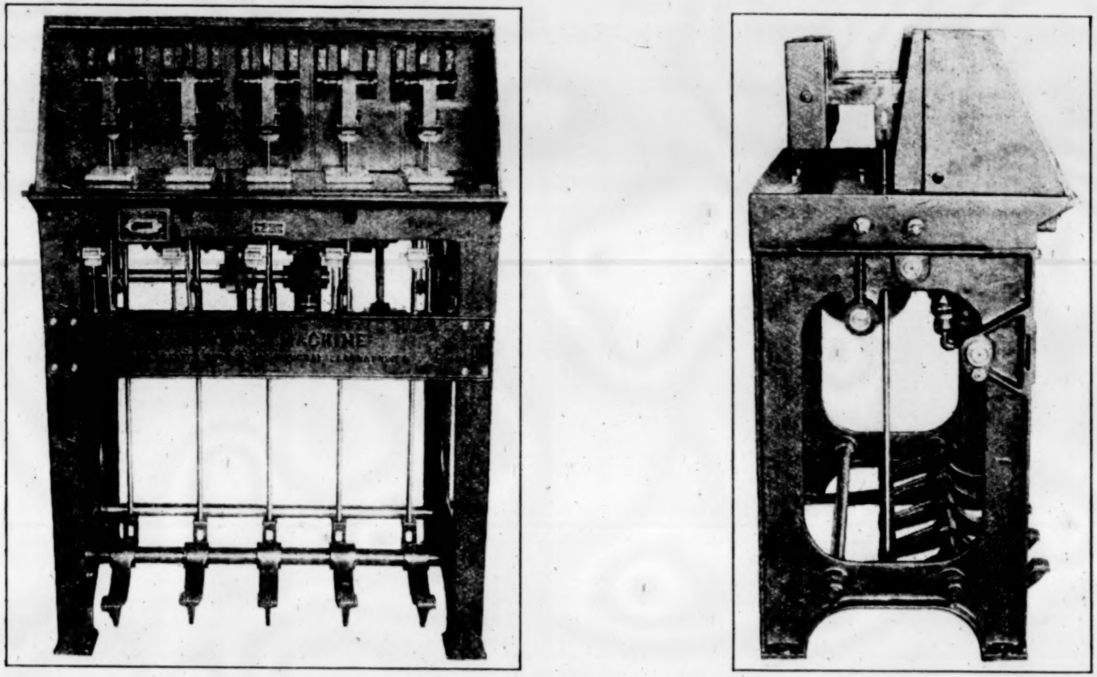
1. The test should make it possible to predict the life of a belt in service or at least to estimate its life when compared with another belt tested in the same manner.

2. The tests should require a minimum of time and material.
3. The equipment should be relatively inexpensive.
4. It should be possible to test several small representative samples at the same time.

It has long been realized that the industry has no satisfactory laboratory methods of predicting the life of a belt under actual service conditions. Tensile strength, stretch and friction tests are used for factory control, development, and specification purposes, but they provide no measure of life under service conditions. Dynamometer testing machines are used by the prominent belting manufacturers for making power and life tests under conditions simulating those in service. A considerable amount of testing of this kind has been done in the last few years and the present high quality of rubber belting is in a large measure due to a careful study of such results in comparison with the service records of the same belts in the field. It is readily seen, however, that this test is more applicable to development work than to factory control or specification purposes. Even when the tests are greatly accelerated, as, for example, by running four-ply belting on 4-in. pulleys at a speed of 1000 ft. per minute with a slip of 1 per cent and with a pull as high as 23 lb. per inch per ply, it has several disadvantages, including:

1. Several hundred hours are required before a high grade belt will fail.
2. About 13 ft. of belting is required for each test sample. This adds materially to the cost of the test and is a burden on the purchaser.
3. The equipment is expensive and constant attention is necessary throughout the test, making the labor cost of the test high.

The problem before the committee is to develop a test that will not have these objectionable features and which will yield results that are in accord with the quality of the belting as indicated by service tests on actual installations. Many ideas have been tried and much thought has been given to what seemed an insurmountable problem. The committee has finally decided upon a flexing type of machine originally designed by the General Laboratories of the United States Rubber Co., as the most satisfactory apparatus for this purpose. This machine has been used in the development of tires and as the flexing action of tires in service is somewhat analogous to that in belting, it is believed that this machine will prove satisfactory. The following is a brief description:

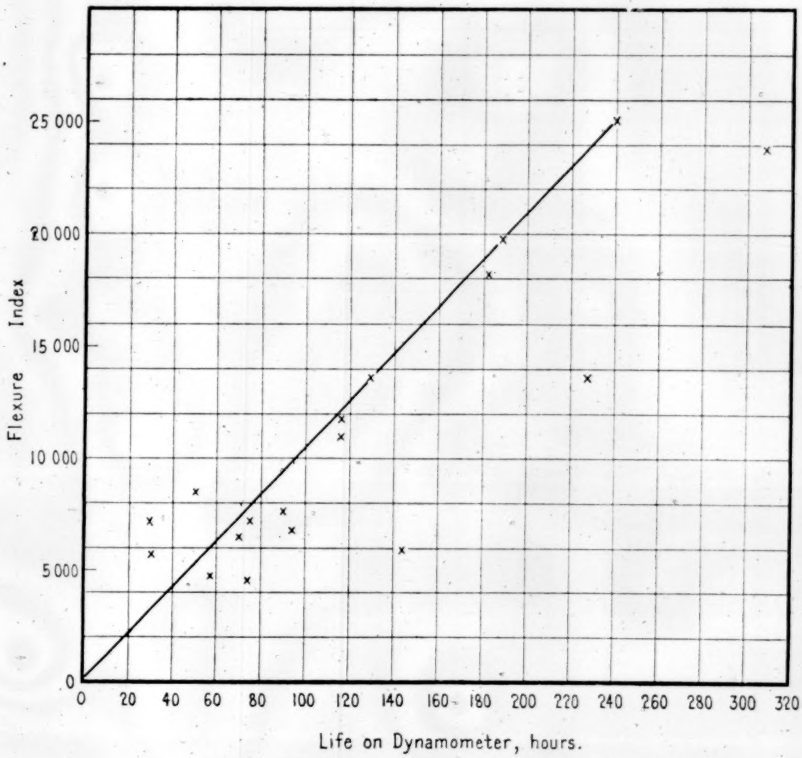


(*a*) Front view, showing specimens in positions.

(*b*) End view, showing loading weights.

FIG. 1—Flexing Machine for Rubber Belting.

The machine is known as a five-head flexing machine and will test five samples of belting at one time. The size of the test sample is 1 by 8½ in. The sample is bent around a 1¼-in. mandrel, the arc of contact being 135 deg. The ends of the sample are gripped by clamps and the action is to oscillate the sample back and forth over the madrel by means of a suitable motor-driven mechanism. The total travel of the sample in one direction is 2⅝ in. or 5¼ in. complete travel for one cycle. The speed is about 170 strokes per minute and the average life of sample of high-grade belt is about four hours. The machine is approximately 15 in. high overall and occupies a floor space of about 26 by 38 in. It is driven by a ¼-h.p., 1750 r.p.m. motor attached to the frame of the machine. Fig. 1 is a photograph of the latest type of machine which embodies the experience gained in the preliminary test with a specially constructed machine.



Flexing hubs, 1¼ in. in diameter.
Cycles per minute, 179.
Ply of sample, 4.
Size of sample, 1 by 10 in.
Weight per ply, 12½ lb.

Dynamometer pulleys, 4 in. in diameter.
Lineal speed of belt, 1000 ft. per minute.
Size of belt, 4 in. 4 ply.
Tension, tight side (T_1), 23 lb. per in. per ply.
Slip, 1 per cent.

FIG. 2.—Showing Relation Between Flexing Index and Life in Dynamometer Machine.

Six additional machines are being constructed and it is expected that all will be in operation in the laboratories of the committee members by June of this year.

As soon as it was decided to adopt tentatively this machine, considerable work was done to show whether the results obtained with it are comparable to the life of a belt on a dynamometer machine—the latter test having shown by experience that its results are in reasonable accord with the life actually obtained in service. Fig. 2 shows the relation between the results obtained with the first experimental flexing machine and those obtained on samples of the same belting with the dynamometer machine. The life of the sample on the flexing machine has been indicated as the "flexing index" and is the number of passes of the sample over the $1\frac{1}{4}$-in. mandrel before ply separation occurred. The life of the sample on the dynamometer machine is expressed in hours. It is evident that, barring three points, there is a reasonable proportion between the results with the flexing machine and those with the dynamometer machine. The problem now before the committee is for each member to corroborate this curve and determine to his own satisfaction whether the flexing index is a reasonably reliable indication of the life of a belt in service.

Aging Test:

The Sub-Committee on Aging Tests, under the chairmanship of J. P. Coe, is collecting experience data and information on the various tests which are in use for this particular characteristic. However, no report is as yet available on this work.

Oil and Gasoline Tests:

The committee in its report last year referred to the development of a test for hose used for conveying oil and gasoline. Further investigation on this subject has indicated comparatively little interest in such a project and consequently the proposal to develop a standard test has been abandoned.

This report has been submitted to letter ballot of the committee, which consists of 43 members, of whom 34 have voted affirmatively, none negatively, and 9 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. FARMER,
Chairman.

E. H. GRAFTON,
Secretary.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS

Committee D-13 on Textile Materials held two meetings during the past year. The fall meeting was held at Greenville, S. C., on October 4 and 5. The spring meeting was held at Providence in conjunction with several other committees of the Society on March 18 and 19. Both meetings were well attended. Both meetings were innovations for Committee D-13, the meeting at Greenville being the first meeting of a committee of the Society held in the South and the meeting at Providence being the first joint meeting of Committee D-13 with other standing committees. Both meetings were quite satisfactory.

Four new sub-committees were authorized during the year:

Sub-Committee XVII on Light and Medium Cotton Fabrics;
Sub-Committee XVIII on Sugar Bags;
Sub-Committee XIX on Worsted and Woolen Yarns;
Sub-Committee XX on Worsted and Woolen Fabrics.

Sub-Committee XVII on Light and Medium Cotton Fabrics may be considered as a recognition of the value of mechanical tests applied to the heavier cotton fabrics and the desirability of extending their use to the lighter cotton fabrics as a ready means of ascertaining the relative values of specified characteristics of the finished product.

Sub-Committee XVIII on Sugar Bags is an outgrowth of the development of the Standard Specifications and Tests for Osnaburg Cement Sacks (D 205 - 25). The work could have been done by Sub-Committee X on Osnaburg Cement Sacks, but it was considered by all concerned that a new sub-committee dealing with jute products would function better for this purpose. It is understood that Sub-Committee X and Sub-Committee XVIII have mutual interest as members of both sub-committees are interested in both cotton and jute bags and bagging materials.

Sub-Committees XIX on Worsted and Woolen Yarns and XX on Worsted and Woolen Fabrics have been formed so as to segregate the work of Sub-Committee XII which now covers only Raw Wool but which originally covered worsted and woolen yarns and fabrics also.

This arrangement leaves some overlapping of the activities of Sub-Committees XII and XIX and of Sub-Committees XIX and XX but only in so far as this is necessary by the nature of the case.

These four new sub-committees have not yet developed any specifications to a definiteness to warrant proposing a tentative standard.

Committee D-13 submits two new tentative standards, appended hereto:[1]

1. Tentative Specifications for Tolerances and Test Methods for Rayon;
2. Tentative Specifications for Tolerances and Test Methods for Electrical Silk and Cotton Tapes.

It is interesting to note in connection with the proposed Tentative Specifications for Tolerances and Test Methods for Rayon that within a period of one year from the time the Sub-Committee on Rayon was formed a quite comprehensive tentative standard for this newest of textile fibers, which is a product of manufacture, was prepared in a form to be submitted for publication. This is in part accounted for by the rapid increase in the consumption of this product and by the fact that the tentative standard rests very largely on the results of the experience with one of the oldest textile fibers, raw silk, which like the rayons is a more or less continuous thread not made up of short fibers spun together.

The proposed Tentative Specifications for Tolerances and Test Methods for Electrical Cotton Tapes is the first concrete output of the work of Sub-Committee XIII on Narrow Fabrics and indicates very strongly a tendency toward a division of the field covered by this sub-committee.

Committee D-13 submits fifteen new tentative definitions as given below to become a part of the present Tentative Definitions of Terms Relating to Textile Materials (D 123 - 22 T). Committee D-13 at the suggestion of Sub-Committee V on Nomenclature and Definitions plans to incorporate these fifteen definitions with those now published as tentative in the Tentative Definitions D 123 - 22 T and include those that are already standard, appearing in the Standard Specifications for Imperfections and Tolerances for Square-Woven Tire Fabrics (D 122 - 25) and in the Standard Specifications for Imperfections and Tolerances for Cord Tire Fabrics (D 179 - 25). The incorporation of all the definitions relating to textiles in one standard will make possible a grouping of the definitions that will permit of ready reference that is not possible with them scattered through several standards and tentative standards. The new tentative definitions of terms are as follows:

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[1] See pp. 1071 and 1077.—ED.

Standard Atmosphere.—For the purposes of moisture regulation and definition, a standard atmosphere shall be an air condition in which there is a relative humidity of 65 per cent at a temperature of 21° C. (70° F.).

Standard Condition.—Wherever the term "standard condition" is used in reference to the moisture condition of any textile material it shall be understood to mean the condition of the material when it is in moisture equilibrium with a standard atmosphere.

Regain (Moisture Regain).—The percentage of moisture present in a textile material calculated on its absolute dry weight.

Standard Regain.—In the case of any specific kind of textile fiber, an agreed or officially adopted percentage allowance of moisture added to the absolute dry weight of the material to determine its standard weight.

Standard Weight.—In the case of a textile material, a weight equal to its absolute dry weight plus its standard regain.

Moisture Content.—The terms moisture, moisture content or percentage of moisture applied to a textile material shall mean the percentage of moisture present in the material calculated on its net weight.

Yarn.—An assemblage of fibers or filaments of animal, mineral, or vegetable origin, either natural or manufactured, twisted or laid together forming a strand or group of strands for use in weaving, knitting, or forming in any manner into textile fabrics.

Cord.—A string or small rope of fibrous material made by twisting together, generally with hard twist, several yarns and used for tying, binding, lacing, etc., and weaving or laying very heavy fabrics.

Thread.—A fine cord composed of two or more yarns twisted together and used for sewing purposes.

Lea.—The division of a hank (840 yd.) of cotton yarn, 120 yd. made up of 80 turns on a standard cotton reel. Also a hank of linen yarn, 300 yd., and used as the basis of the linen yarn count.

Count.—In the case of cotton yarn, the number of 840 yd. hanks contained in one pound (avoirdupois 7000 grains) of the yarn at standard condition.

Ends.—The individual warp yarns running lengthwise of the fabric.

Picks.—The individual weft or filling yarns running across the fabric.

Gage.—In the case of knit goods, the closeness of the wales, that is, the longitudinal row of loops per inch, a measure of the fineness of the fabric. It is expressed by the number of needles in 1½ in.

Plain Weave.—The fabric pattern in which each yarn of the weft passes alternately over and under a yarn of warp.

Committee D-13 also submits suggested General Methods of Testing Textile Fabrics. These are published as an appendix to this report to elicit comments and suggestions. They are not to be construed by the Society as a formally proposed revision of the Standard Methods of Testing Cotton Fabrics (D 39 - 24). These revised methods have been suggested by a growing understanding that the Standard Methods D 39 - 24 are quite generally applicable to all kinds of textile fabrics and are not specific tests for cotton fabrics alone. It is hoped that by publication as information more discussion will result before an attempt at formal revision is made as it is desirable that the revision should be as compact and at the same time as complete as possible. With sub-committees at work on nearly all textile materials in common use it is thought that a revision can be made so as to stand for a considerable period of time without repeated revisions.

Committee D-13 has six tentative standards ready to advance to standard but is continuing them as tentative until next year, the regular period for the adoption of new standards, in compliance with the suggestion of the Executive Committee. The six tentative standards are:

Tentative Specifications for Tolerances and Test Methods for Cotton Yarns (D 180 - 25 T);

Tentative Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204 - 25 T);

Tentative Specifications for Textile Testing Machines (D 76 - 22 T);

Tentative Specifications for Tolerances for Numbered Duck (D 230 - 25 T);

Tentative Specifications for Tolerances and Test Methods for Knit Goods (D 231 - 25 T);

Tentative Definitions of Terms Relating to Textile Materials (D 123 - 22 T).

Sub-Committee VI on Tire Fabrics is being reorganized to embrace specifications for all kinds of tire fabrics including bicycle, chafing strip, breaker, builder, etc.

It may be of interest to point out the rapid expansion of the activities of Committee D-13 within the last few years wherein it has grown from a few members more particularly interested in cotton products to more than one hundred and fifty members interested in practically all of the textile products in common use, including rope and cordage and asbestos textiles.

The contact of the groups interested in special textile products has led each to see that in so far as testing machines and test methods and tolerances are concerned, they can all meet on a common ground to the advantage of all.

The recommendations contained in this report have been submitted to letter ballot of the committee, consisting of 163 members, with the following results:

Items	Affirmative	Negative	Not Voting
NEW TENTATIVE STANDARDS			
Tentative Specifications for Tolerances and Test Methods for Rayon	52	1	37
Tentative Specifications for Tolerances and Test Methods for Electrical Cotton Tapes	52	4	34
New Tentative Definitions Relating to Textile Materials	79	0	11

This report has been submitted to letter ballot of the committee, which consists of 163 members, of whom 86 have voted affirmatively, none negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

W. F. EDWARDS,
Chairman.

K. B. COOK,
Secretary.

EDITORIAL NOTE

The proposed Tentative Specifications for Tolerances and Test Methods for Rayon; and for Tolerances and Test Methods for Electrical Silk and Cotton Tapes were accepted for publication as tentative and appear on pages 1071 and 1077.

The proposed revisions of the Tentative Definitions of Terms Relating to Textile Materials, involving the inclusion of new tentative definitions submitted in the report and a rearrangement whereby a number of definitions appearing in other standards were to be included with the tentative definitions, were accepted. The tentative definitions as revised appear on page 1080.

APPENDIX

PROPOSED GENERAL METHODS
OF
TESTING TEXTILE FABRICS

Scope. 1. The following General Methods are intended to be applicable for testing textile fabrics. Where a material requires special treatment, specific methods will be described as they are developed for that material and such special tests shall have precedence over the general method.

I. CONDITION

Dry Condition. 2. The dry condition of textile fabric shall be understood to be absolute dryness obtained by placing material in a ventilated drying oven maintained at a temperature of 100 to 110° C. (212 to 230° F.) and drying to constant weight as determined by two consecutive weighings without removal from the oven, to be taken not less than 10 minutes apart, and to show a further loss of not more than 0.1 per cent of the previous weighing.

Standard Condition. 3. The standard condition of textile fabric shall be understood to be the condition which it assumes on exposure for at least four hours, to an atmosphere having a relative humidity of 65 per cent at 70° F. (21.1° C.).

II. TEST METHODS FOR WOVEN TEXTILE FABRICS

(*A*) *Length*

Length. 4. (*a*) If the fabric weighs more than 6 oz. per sq. yd. the length of a roll or piece shall be determined by running the cloth over a measuring drum of known circumference, from which the yardage is registered by a dial or counter driven by a chain or other positive or non-slip mechanism. Just enough uniform tension[1] is to be used on the cloth to keep it running flat and true.

(*b*) If the fabric weighs 6 oz. per sq. yd. or less, its length shall be determined by running it through a folding device which will fold a known length of fabric at each stroke. The yardage is registered by a dial or counter which shall be accurately calibrated against the length of fabric per stroke.

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[1] It has been suggested that a uniform tension of 2.5 times the weight of five running yards of the fabric will be sufficient to keep the fabric flat and preserve a proper relation for comparison of different fabrics. Invitation is extended to report the results of such tests upon different fabrics.

(B) *Width*

Width.

5. (*a*) The width of a roll or piece shall be determined at five different places uniformly distributed along the full length of the roll or piece, and may be determined at the same time as the total length.

(*b*) The average of the five measurements shall be the width.

(C) *Weight*

Normal Weight.

6. (*a*) *Preferred Method.*—The net weight of the roll or piece from which covering and binding have been removed shall be determined. The net weight of the roll or piece divided by its superficial area in square yards shall be taken as the normal net weight per square yard.

(*b*) *Alternative Method.*—Three samples of known area, to contain not less than 4 sq. in. each, shall be stamped (preferably cut with a steel die) from one end of the roll or piece and quickly weighed. The normal square yard weight shall be computed from the average weight of these three samples.

(*c*) In referee tests, the fabric shall be brought to standard condition, as specified in Section 3, before weighing.

Retest.

7. If by the first tests the fabric fails to meet the requirements of the specifications, a second sample shall be tested. The second sample may be taken from the center of the roll or piece or from the end opposite the one from which the first sample was taken.

Moisture Content and Regain.

8. The difference between the normal weight of the fabric and the dry weight is the amount of moisture present.

(*a*) When computed as percentage of the normal weight this is the *Moisture Content* of the material.

(*b*) When computed as percentage of the dry weight, this is the *Moisture Regain* of the material.

(D) *Number of Threads per Inch*

Number of Threads per Inch.

9. (*a*) Where there are more than 25 threads per inch, the number of threads per inch or count of the fabric shall be determined by counting a space not less than 1 in. in at least five different places in the roll or piece. Where there are 25 or fewer threads per inch, a 3-in. gage length shall be used.

(*b*) The average of the five determinations shall be the count.[1]

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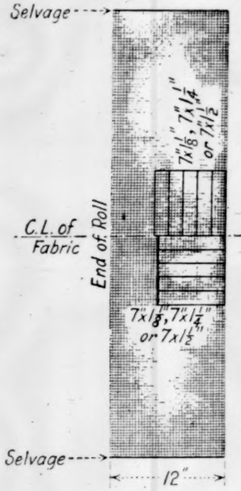
[1] For tire fabric used for carcass building the number of threads per inch shall be determined by counting a space of 10 in. in at least five different places in the roll or piece, and the average of the five determinations shall be the count.

(*E*) *Thickness*

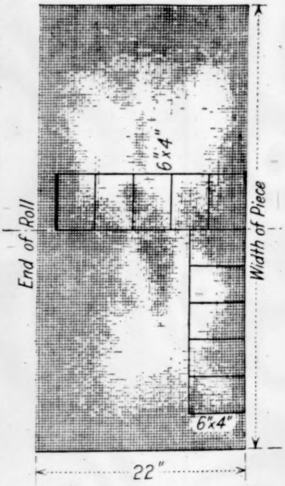
Thickness. 10. (*a*) The thickness shall be measured by an automatic micrometer which presses upon a circle $\frac{3}{8}$ in. in diameter of the fabric with a pressure of 6 oz., and which is so mounted as to make measurements 6 in. from the selvage.

TABLE I.—TENSILE STRENGTH TEST METHODS.

Method No	1 Strip Method	2 Grab Method	3 Single Strand[1]
Length of specimens, in	7	6	..
Width of specimens, in.:			
If thread count is 80 or over	$1\frac{1}{8}$		
If thread count is 50 to 80	$1\frac{1}{4}$	4	..
If thread count is less than 50	$1\frac{1}{2}$		
Ravelled to standard or specified threads per — in	1	..	..
Minimum width of bottom or back jaws, in	$1\frac{1}{2}$	2	..
Width of top or front jaws, in	$1\frac{1}{2}$ (min.)	1	..
Distance between jaws, in	3	3	10
Speed of pulling jaw, in. per minute	12	12	12
Number of specimens each, warp and filling	5	5	20 strands


Selvage
$7''\times1\frac{1}{8}''$, $7''\times1\frac{1}{4}''$ or $7''\times1\frac{1}{2}''$
C.L. of Fabric
End of Roll
$7\times1\frac{1}{8}$, $7''\times1\frac{1}{4}''$ or $7\times1\frac{1}{2}''$
Selvage
12"

No. 1


End of Roll
6"×4"
Width of Piece
6"×4"
22"

No. 2

---

[1] The distance between jaws shall be 10 in. measured along the length of the cord, between the points where the cord is actually gripped by the clamps. An initial load of 50 g. shall be applied before the second clamp is tightened.

NOTES.—1. When material is less than 24 in. wide, the swatch shall be cut 24 in. long and the test specimens shall be laid out in such a manner that no part of any specimen shall come within 2 in. of either selvage.

2. When the specified number of threads or picks per inch is in fraction, the number of threads broken shall include the fraction as a full thread.

(*b*) At least five measurements at different portions of the roll or piece shall be made, and the average shall be the thickness of the fabric.

(*F*) *Strength*

Tensile Strength.

11. Tensile strength tests shall be made by one of the three methods described as follows in detail, and fabrics shall be tested by the method shown for the classification under which they fall. In each case the results shall be recorded separately for warp and filling.

For the determination of tensile strength a swatch of the length specified in Table I shall be cut the entire width of the cloth and test specimens shall be cut from this swatch according to the respective diagrams shown at the bottom of Table I.

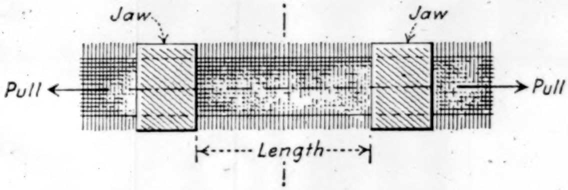


FIG. 1.—Illustration of Strip Test.

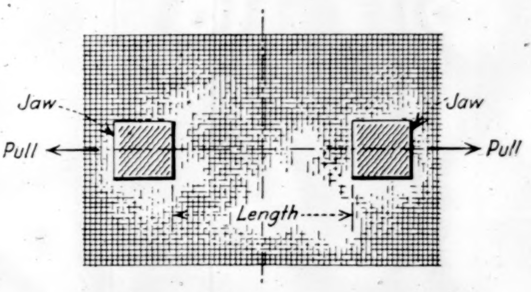


FIG. 2.—Illustration of Grab Test.

Two methods of determining the tensile strength shall be recognized.

Strip Test.

(*a*) *Strip Test* (*Fig. 1*).—Under this method a long narrow strip of the fabric shall be clamped at each end by the jaws of the testing machine and strained to the point of rupture.

Grab Test.

(*b*) *Grab Test* (*Fig. 2*).—Under this method the testing machine jaws, each of definite width, shall be made to reach into the body of a rectangular piece of fabric and shall be clamped a definite distance apart. Care shall be taken that the same set of threads are embraced by both pairs of jaws. The specimen shall then be strained to the point of rupture.

12. The following table indicates which of the above tensile test methods and humidity conditions are recommended for the kinds of fabrics enumerated:

TABLE II.—TENSILE STRENGTH: TEST METHOD CLASSIFICATION.

Name of Fabric	Test Method No.	Humidity Conditions
TIRE FABRICS, including		
Carcass building fabric	1	Test specimens shall be tested in a dry condition as defined in Section 2. They shall be taken one at a time from the drying oven and broken in the testing machine within 30 seconds from the time of removal from the oven.
Chafing strip	1	
Breaker strip	1	
Cord fabric	3	
DUCKS, including		
Hose duck	2	Standard conditions as specified in Section 3.
Belt duck	2	
Tent duck	2	
Army duck	2	
Enameling duck	2	
Sail duck	2	
Numbered duck	2	
DRILLS	2	(*a*) Specimens may be broken in dry condition as specified above for tire fabrics, such tests to be captioned, "Tested Bone Dry." (*b*) Specimens may be tested in standard condition as specified in Section 3.
SHEETINGS	2	
OSNABURG	2	
COUTILS	2	
BALLOON CLOTH[1]	1	
WING FABRIC[2]	..	Exposed before testing for at least two hours in an atmosphere of 65 per cent relative humidity of 70° F. and tested in this atmosphere.

[1] Balloon cloth shall be tested on machines of the inclination balance type with maximum capacity of 400 lb.

[2] The elongation of wing fabric shall be observed for each specimen when subjected to loads of 10 lb., 20 lb., and 70 lb. Wherever possible autographic records shall be taken.

NOTE.—Fabrics not included in the above list will be given a test method classification by Committee D-13 on application of those interested.

(G) *Crimp*

Crimp. 13. Mark two parallel lines on the fabric at least 6 in. apart. Ravel out 4 threads long enough to extend about 2 in. beyond each mark. These threads shall be straightened by a machine which applies a load to each thread. The load in grams to be used is 156 divided by the equivalent single size of the thread. The crimp is the ratio between the final length of the thread and its original length in the cloth.

(H) *Elongation*

Elongation. 14. By means of a curve plotting device, attached to the breaking strength machine, a curve can be obtained from which the elongation at any load can be read. Elongation shall be expressed as per cent of the original length.

REPORT OF COMMITTEE D-14
ON
SCREEN WIRE CLOTH

Two meetings of Committee D-14 have been held during the past year, one at the last annual meeting in Atlantic City and one at Providence, R. I., on March 18, 1926.

During the past two years Sub-Committee IV on Tests has been conducting atmospheric exposure tests on seven grades of non-ferrous screen wire cloth.

Although this work has been carried out under the direction of Sub-Committee IV, other members of the main committee have cooperated by furnishing material and facilities. Assistance was rendered by both producers and non-producers on the committee. Some producers furnished the standard 0.0113-in. wire and others wove it into 16-mesh cloth. The cloth was put into 30 by 36-in. copper frames, 30 by 36-in. wooden frames and 15 by 15-in. wooden frames by non-producers of cloth; the large sizes by the Cincinnati Fly Screen Co. and the small size at the U. S. Bureau of Standards. The Bureau of Mines, Pittsburgh, Pa., the Bureau of Standards, Washington, D. C., the Bureau of Lighthouse Depot, Portsmouth, Va., and the Panama Canal, Canal Zone, are four government agencies that are cooperating by furnishing facilities and personnel for carrying out the exposure tests.

In the Report of Committee D-14 for 1925, an outline of the proposed tests was given. The report gave the chemical composition of the seven materials used, the composition of the paint used in painting the wooden frames, photographs of the three types of frames used, and views of the frames fastened in place for exposure on the roof of one of the buildings at the Bureau of Standards. Since the last report of the committee the other test frames have been placed in position at the Bureau of Lighthouses, Portsmouth, Va., the Bureau of Mines at Pittsburgh, Pa., and the Panama Canal, Balboa Heights, Canal Zone. In each case they were placed on the roof of a building.

Figure 1 shows the 21 frames in position for atmospheric exposure on the roof of the Auditorium, Bureau of Mines, Pittsburgh, Pa. This location represents industrial atmosphere. These specimens were fastened in position on October 29, 1925.

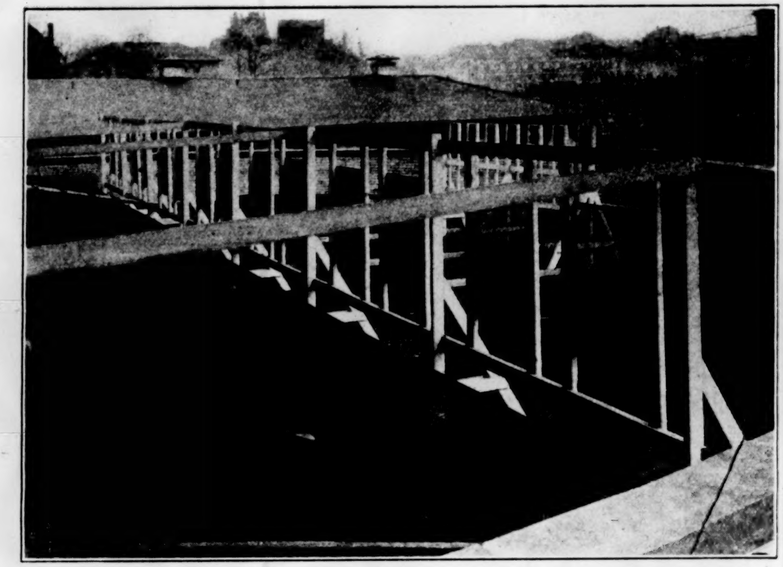


FIG. 1.—Showing Mounting of Screens at Bureau of Mines, Pittsburgh, Pa.

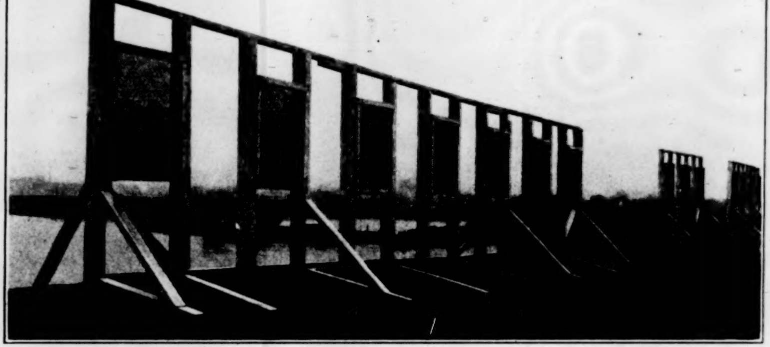


FIG. 2.—Showing Mounting of Screens at Bureau of Lighthouses, Portsmouth, Va.

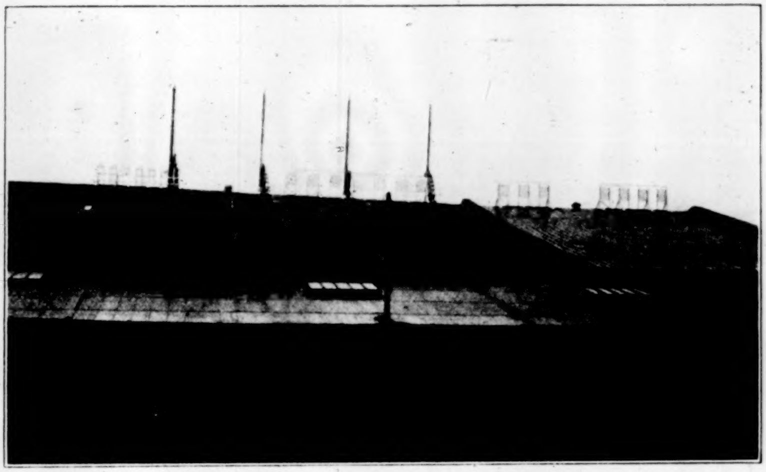


FIG. 3.—Showing Mounting of Screens at Bureau of Lighthouses, Portsmouth, Va.

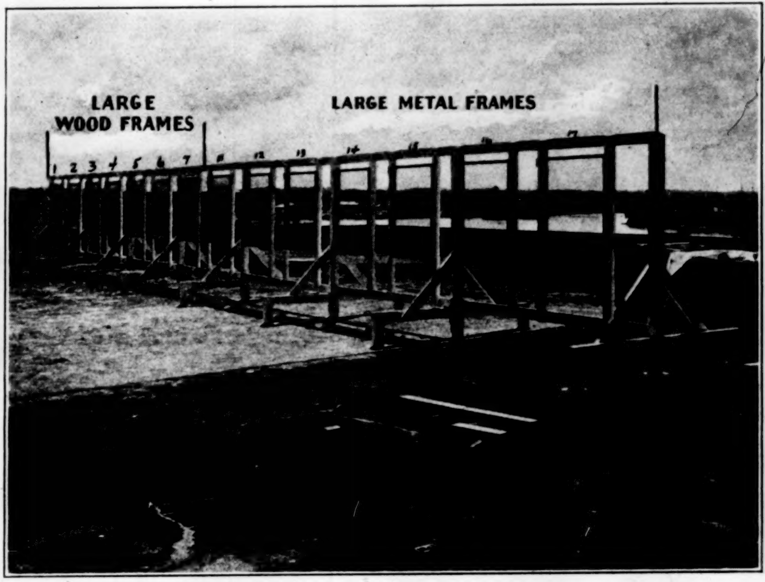

LARGE WOOD FRAMES
LARGE METAL FRAMES
1
2
3
4
5
6
7
11
12
13
14
15
16
17

FIG. 4.—Showing Mounting of Screens at Panama Canal.

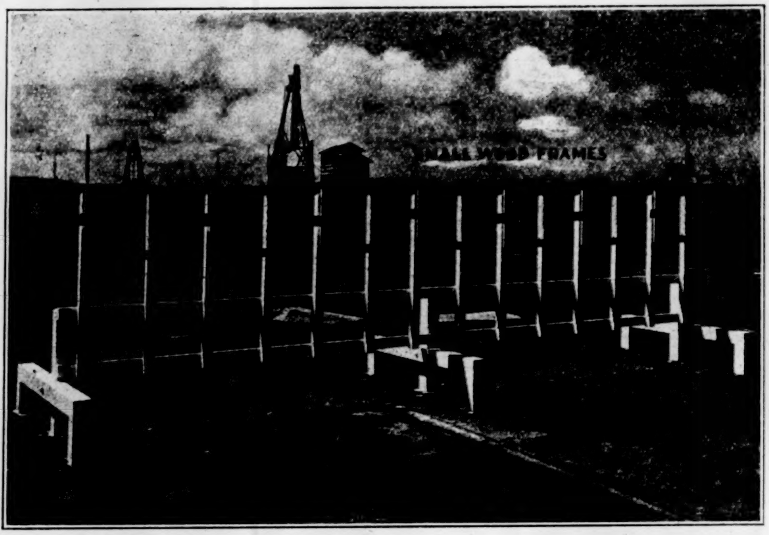

SMALL WOOD FRAMES

FIG. 5.—Showing Mounting of Screens at Panama Canal.

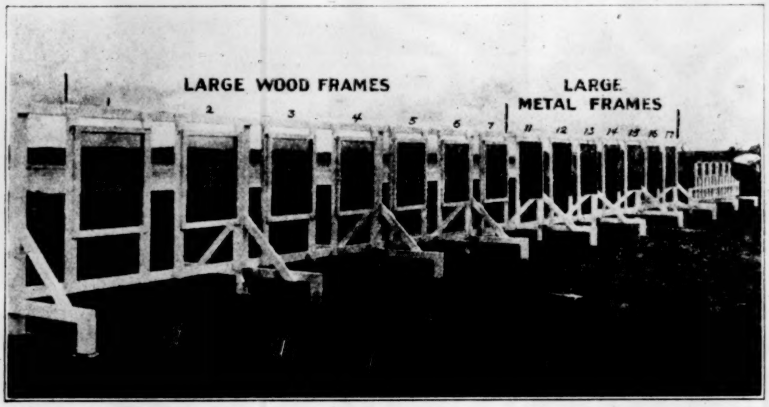

LARGE WOOD FRAMES
LARGE METAL FRAMES
1
2
3
4
5
6
7
11
12
13
14
15
16
17

FIG. 6.—Showing Mounting of Screens at Panama Canal.

Figures 2 and 3 are views of the series mounted on the roof of a building of the Bureau of Lighthouses at Portsmouth, Va. This location represents conditions along the seacoast. The frames were put in position for exposure October 28, 1925.

Figures 4, 5 and 6 are views of the sets of frames fastened in position on the roof of a building at the Panama Canal. These frames were exposed November 16, 1925. These tests are being made here to determine the behavior of the material in tropical seacoast atmosphere.

Reports from the Bureau of Standards and the Bureau of Mines do not show any marked differences in the performance of the materials. Changes in color, which have tended to bring the screens to a color quite similar to each other, are the most noticeable changes the specimens have undergone since being exposed.

These exposures will all be periodically examined by representatives of the committee, and reports of their conditions obtained, although it is anticipated that considerable time will elapse before any actual failures will be noted.

At its last meeting, the committee voted to solicit a fund of $200 from the manufacturing members to defray certain expenses incidental to the erection and inspection of certain of the tests. At this time $100 of this amount has been subscribed.

As a further portion of its program, Sub-Committee IV has conducted through the cooperation of the Bureau of Standards an extensive study of the corrosive properties of the various screen wire cloths under accelerated laboratory conditions as well as a determination of the mechanical properties of the wire cloths and the component wires. A description of this work appears in an appendix to this report as a paper by G. W. Quick entitled, "Laboratory Tests on Non-Ferrous Screen Wire Cloth."

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 12 have voted affirmatively, none negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

R. W. Woodward,
Chairman.

W. H. Bassett,
Secretary.

APPENDIX

LABORATORY TESTS ON NON-FERROUS SCREEN WIRE CLOTH[1]

BY G. W. QUICK[2]

INTRODUCTION

The U. S. Bureau of Standards was requested by Committee D-14 on Screen Wire Cloth of the American Society for Testing Materials to make some laboratory tests on several kinds of non-ferrous screen wire cloth. The materials were from the same special rolls of stock as the specimens which are exposed in frames to atmospheric corrosion; the cloth being 16-mesh woven from standard 0.0113-in. diameter wire. An earlier report of Committee D-14[3] gave the source and description of these materials, including the chemical composition determined by the Bureau of Standards. The nominal compositions of the materials with the numbers used to designate each kind of cloth are as follows:

DESIGNATION	NOMINAL COMPOSITION
No. 1	copper 90 per cent, zinc 10 per cent
No. 2	copper 80 per cent, zinc 20 per cent
No. 3	copper 75 per cent, nickel 20 per cent, zinc 5 per cent
No. 4	nickel 70 per cent, copper 30 per cent (approx.)
No. 5	copper (unalloyed)
No. 6	copper 98 per cent, tin 2 per cent
No. 7	copper 95 per cent, aluminum 5 per cent

The committee desired to have laboratory test data on these materials permanently recorded for general information. The laboratory tests were to include tests for strength of the cloths and resistance to corrosion in some accelerated corrosion tests.

ACCELERATED CORROSION TESTS

The relative corrodibility of the different materials was determined by (1) salt-spray or "mist" test and (2) the intermittent repeated immersion test.

Salt-Spray Test:

The equipment for the salt-spray tests has been described by Rawdon, Krynitsky and Finkeldey.[4] A change has been made in the box described in the paper referred to. The box is now arranged so that the condensed vapor from the specimens cannot drip back into the reservoir and contaminate the salt solution with any of the products of corrosion; the dripping being trapped in the mist chamber.

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[1] Published by permission of the Director of the Bureau of Standards of the U. S. Department of Commerce.

[2] Assistant Scientist, U. S. Bureau of Standards, Washington, D. C.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 384 (1925).

[4] "Types of Apparatus Used in Testing the Corrodibility of Metals," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 717 (1924).

The solution used in the salt-spray test was a normal solution of sodium chloride. The specimens were 2-in. square samples of the wire cloth. These specimens were hung in duplicate on glass hooks which in turn were supported on a horizontal glass rod. The glass hooks had been drawn out to a small size so as to pass through the mesh of the wire cloth; the hooks were passed between the second and third strands. The seven kinds of specimens were in a continuous line from one of the walls of the box to the middle and repeated from the middle to the other wall, so that the duplicate specimens of a particular kind did not occupy the same relative position in the box. The specimens were given the same numbers as the materials in the atmospheric corrosion tests and the positions in the box were recorded. When the specimens were removed, the glass rod upon which the hooks were supported was withdrawn with the specimens attached and only one specimen was removed from the rod at a time, so as to eliminate the danger of mixing the samples. The specimens were weighed before the test started and at intervals of 72 hours during the test. The corrosion products were removed, as completely as possible, before each weighing. The specimens were gently brushed with a bristle brush in a stream of hot water, rinsed in alcohol and dried in an oven at approximately 50° C. before weighing. The loss of weight after each cycle was noted. Although this treatment did not remove quite all of the salts it did remove most of them, and in all cases the cleaning operation was the same. The test was continued for eight 72-hour cycles, excepting the eighth which lasted 110 hours.

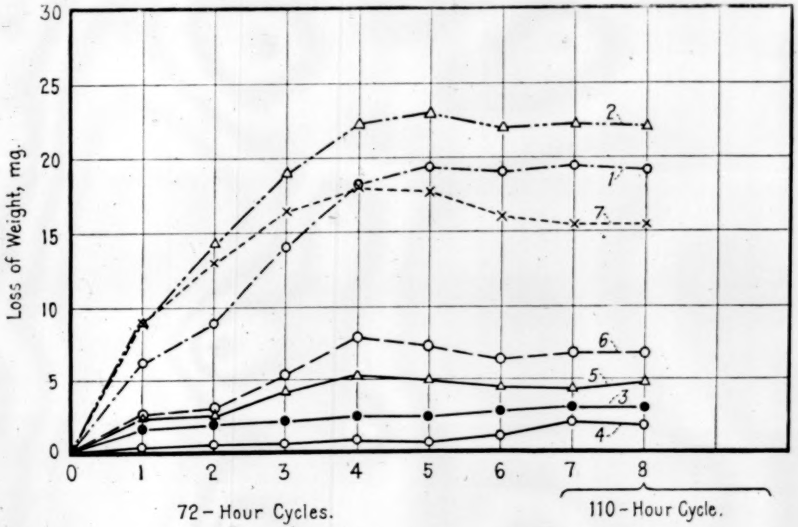

FIG. 1.—Results of Salt-Spray Test; Normal Solution.

Curves showing the loss of weight at the end of each of the cycles for the seven grades of cloth are shown in Fig. 1. The nickel alloys, Nos. 4 and 3, lost the least weight. Nos. 5 and 6, pure copper and silicon-bronze of 98 per cent copper, were next in order, followed by No. 7, an alloy of 95 per cent copper with aluminum. Nos. 1 and 2, the zinc-bearing alloys, lost the greatest weight and of these No. 2, the one of higher zinc content, lost the more weight.

Briefly, it might be said that the nickel alloys were the most resistant in this laboratory test. Of the other alloys, the ones containing the most copper from pure copper down to alloys carrying the greatest amounts of other elements were next in resistance to corrosion. It will be interesting to note how the test specimens exposed in a sea-coast atmosphere behave compared with these results.

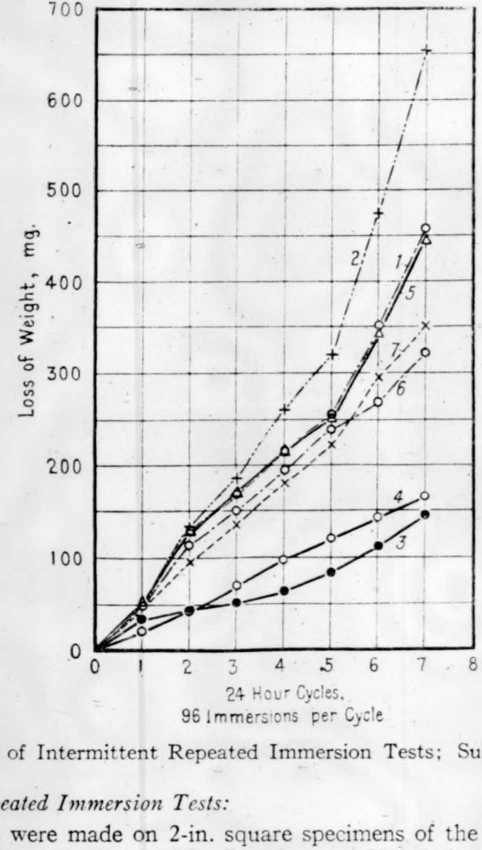

FIG. 2.—Results of Intermittent Repeated Immersion Tests; Sulfuric Acid 0.1 *N*.

Intermittent Repeated Immersion Tests:

These tests were made on 2-in. square specimens of the screen materials by using the apparatus designed by Rawdon and Krynitsky[1] for intermittent repeated immersion or "wet and dry" tests. In this test the specimens are immersed in the solution, withdrawn and held in the air for a period sufficient to permit the specimens to dry before being immersed again. The cycle lasts 15 minutes, for about 13 of which the specimens are in the air. The specimens are weighed at the end of each cycle of 24 hours (96 immersions per cycle). In some cases, on account of poor electrical contact, immersion was not always made at the end of the 15-minute period, and it took longer than 24 hours to complete the 96 immersions; but the full number of 96 was completed for each cycle in these tests.

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[1] *Loc. cit.*

Three solutions were used in these tests: Sulfuric acid 0.1 *N*, sulfuric acid 0.02 *N* and sodium chloride solution 0.5 *N*.

Sulfuric Acid 0.1 N.—At the end of the first cycle all of the samples except the nickel alloys were considerably brighter than in the initial condition; the low brass changed from a golden to a more silvery color, while the reddish copper and bronzes changed to lighter shades. The specimens maintained these distinguishing colors through the series of seven cycles. Figure 2 shows the loss of weight of these specimens during this test. As in the salt-spray test, the nickel alloys lost the least weight and the zinc alloys the greatest weight. The other specimens of copper and the bronzes fell in between as in the case of the salt-spray test, but not in quite the same order.

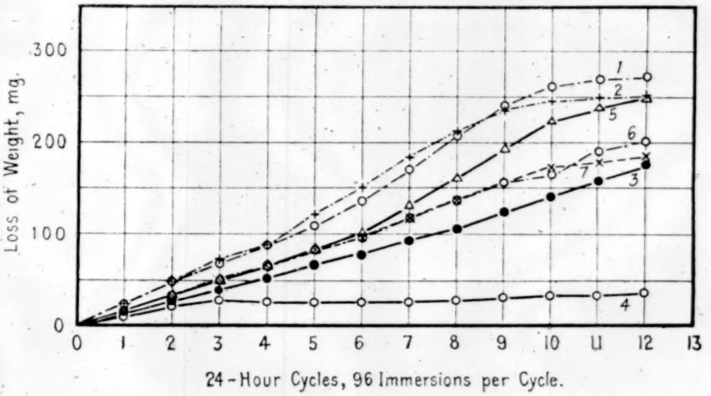

Fig. 3.—Results of Intermittent Repeated Immersion Tests; Sulfuric Acid 0.02 *N*.

Sulfuric Acid 0.02 N.—In this series the test was carried on for twelve cycles of 96 dips each. The results are plotted in Fig. 3. Here again the zinc alloys lost the most weight and the nickel alloys the least, with the other three specimens in about the same order as in the 0.1 *N* H_2SO_4 test. Except that the two nickel alloys are reversed, there is a good qualitative agreement in the two tests. It does not seem that any inferences can be drawn as to the rate of loss of weight as there is no marked change in the slope of the lines during the test.

Sodium Chloride Solution 0.5 N.—In sea water, 80 per cent of the salt is sodium chloride, whereas in our solution practically 100 per cent of the salt present is sodium chloride. This solution can hardly be called artificial sea water. The specimens were run for seven 24-hour cycles between weighings, as in the preceding tests, after which a number of cycles were made consisting of a greater number of dips per cycle. The specimens were cleaned at the end of each cycle before weighing by washing in hot tap water and rinsing in alcohol and ether. At the end of the first cycle the 90 per cent Cu-10 per cent Zn material had assumed a color similar to the original color of the material 95 per cent Cu-5 per cent Al; the 80 per cent Cu-20 per cent Zn alloy had changed to a blue steel color; the 20-per-cent nickel alloy to a yellowish tinge; the 98 per cent Cu-2 per cent Sn material to a lighter bleached color; and the 95 per cent Cu-5 per cent Al alloy to a whitish color similar to the original color of the 70-per-cent nickel alloy. The results are shown graphically in Fig. 4. These curves show the loss in weight to be much in the same order as the salt-spray test and the intermittent repeated immersion tests in dilute sulfuric acid, excepting that the two nickel alloys lost relatively an appreciably greater weight than in the other tests. It may be that the difference in the relative performance is, in part, due to greater ease with which the nickel alloys may have cleaned in this test as compared with the other materials.

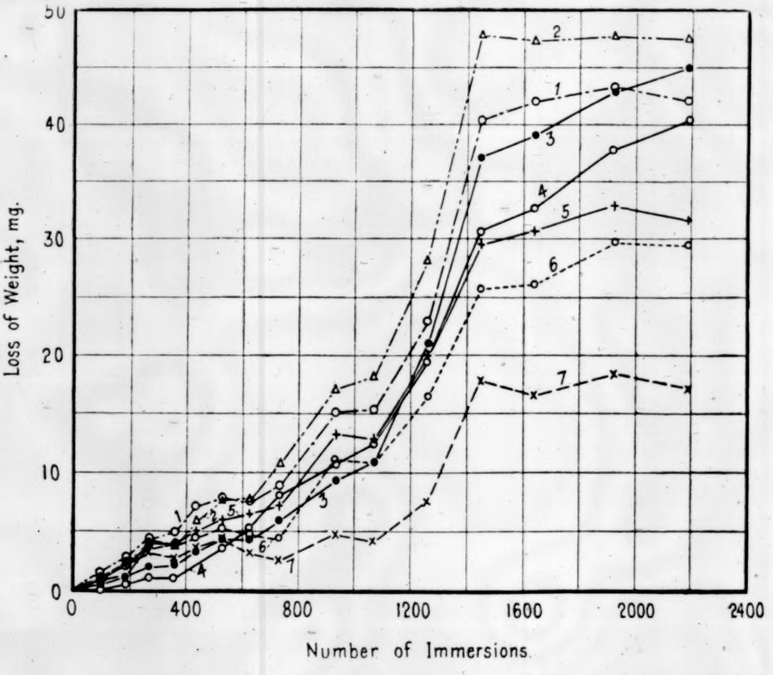

FIG. 4.—Results of Intermittent Repeated Immersion Tests; Sodium Chloride Solution 0.5 *N*.

PHYSICAL TESTS

Tensile Strength:

A 200-lb. capacity Scott tension testing machine was used for making tension tests on specimens of cloth taken both ways from the material. The specimens were of the multiple-strand type. Tests were also made on individual strands of wire by using an especially constructed dead-load equipment; the wires in this test were also taken both longitudinally and transversely.

The first type of multiple strand specimen tried was a straight specimen consisting of 15 strands. These samples gave trouble because they usually broke in the jaws of the grips. This difficulty was overcome by adopting a specimen with a reduced section, the reduction being from 15 wires at each end to 11 wires in the middle section. Figure 5 shows one of those specimens in place in the jaws of the machine. For each of the seven kinds of cloth, five such specimens were taken lengthwise and five across the roll, making 10 specimens for each alloy or a total of 70 specimens. Although the 11 wires in the reduced section extend throughout the specimen, the cross wires bind them to the two extra strands on each side sufficiently to relieve the 11 wires in question of a sufficient portion of the total stress at the ends of the specimen to cause them to fracture in the reduced section.

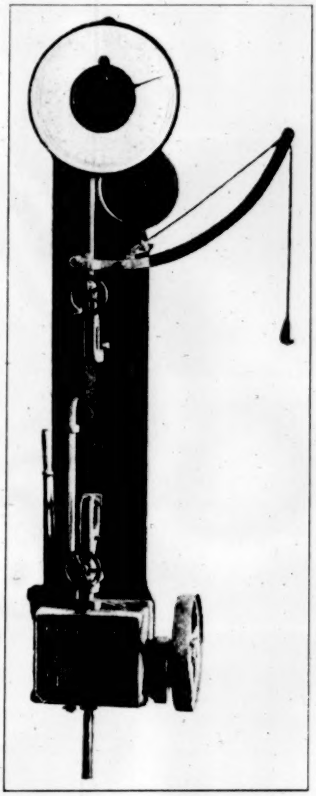

FIG. 5.—Testing Machine with Specimen of Wire Cloth in Position for Tensile Test.

The method of testing the individual wires in tension consisted of having the specimen tied to a fixture and support an adjustable load. The load was applied by adding shot to a container supported by the specimen. When the specimen ruptured, the container and contents were weighed and the unit load computed. Five wires in each direction were tested from each kind of cloth.

The tensile strength of the five samples for each type of specimen taken both ways from the seven kinds of material was averaged. The results are shown graphically in Fig. 6. In all tests the single-strand specimen supported a greater unit load before failure than in the case of the 11-strand specimen.

The shoot wires (taken across the roll) had a greater tensile strength than the warp wires (taken lengthwise) in every test except two, and in these tests the warp wires gave only slightly greater tensile strength values than the shoot wires. For nearly every test there was less difference between tensile strength of the single-strand and 11-strand specimens of shoot wires than for warp-wire specimens. One would expect this latter condition since the shoot wires are more nearly straight than the warp wires and each of the 11 strands bears its portion of the total load with less lateral pressure than the 11-strand warp wires do. In the case of the single-strand warp wire the kinks straighten out in the early part of the test and as the load is increased the specimen is quite like a single strand of the shoot wire. The wires of the 11-strand warp-wire specimen, on the other hand, are interwoven with straight shoot wires which resist the effort of the warp wires to straighten out from the initial load, so that there is an appreciable force holding the wires in a zig-zag line which causes it to rupture at the angles for a smaller unit load than do the single wires.

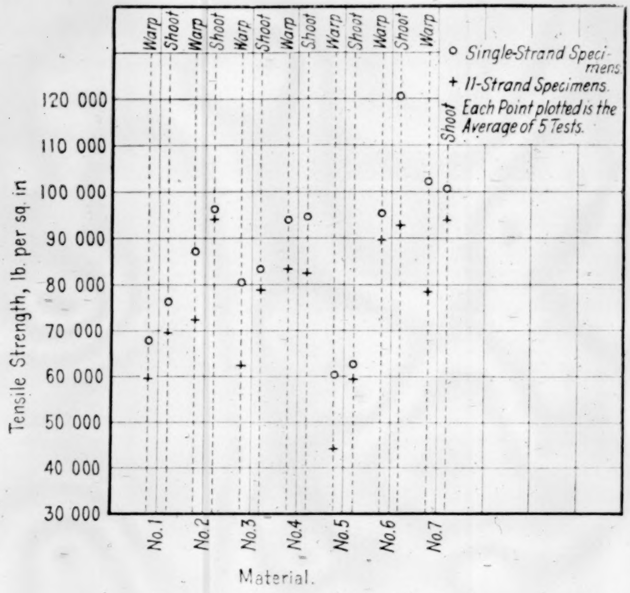

FIG. 6.—Results of Tension Tests.

Erichsen Tests:

Some preliminary tests were made with the Erichsen cupping machine. The marked tendency for the cloth to slip past the grips when pressure was applied was overcome by placing a piece of emery cloth around the faces of the holders. The results were not sufficiently promising to warrant the use of this test for determining the relative strength of the materials. There was no accurate way of telling when failure occurred because of inability to see when the wires first break. The sound produced by the fracture is an unreliable indication of the time of failure. For this reason, this test was discarded and the tension test reported above substituted as a test for relative strength.

REPORT OF COMMITTEE D-16
ON
SLATE

Since the last report of this committee, three well-attended meetings have been held. In accordance with the committee's decision to hold meetings in various slate producing districts, one of these was held at Lake Bomoseen, Vermont, at which time several quarries were visited in Vermont and New York.

During the year the membership has been increased from 14 to 21. Of these, 5 are classed as producers and 16 as non-producers.

The work of Sub-Committee I on Methods of Tests has been concerned largely with a testing program in which the tentative methods proposed last year are being submitted to a thorough trial. In this, the cooperation of three well-known engineering colleges has been secured and they are giving very generous help for which special credit is due to the following: T. R. Lawson of Rensselaer Polytechnic Institute, W. B. Plank and Charles W. MacDougal of Lafayette College, R. J. Fogg and M. O. Fuller of Lehigh University. This testing program is well under way and it is believed that several points of interest will be developed which will result in improvement of the tentative test methods.

Sub-Committees II and III on Hardness and Workability, respectively, have cooperated in their studies and have made satisfactory progress in the design and testing of special apparatus involving rebound, impact, abrasive and scratch methods of test. In view of the close relationship existing between the work of these two committees, it was decided to combine them as a Sub-Committee on Workability. A new Sub-Committee II on Abrasive Hardness was formed to study the problem of wearing qualities of slate when used in floors, treads, etc.

Sub-Committee IV on Electrical Slate is continuing its study of the comparative merits of various resistivity test methods and reports satisfactory progress.

Sub-Committee V on Weathering Characteristics is conducting experiments on freezing tests and accelerated weathering tests, but due to the great resistance of slate to frost action the work to date has not yielded any conclusive results. The fact that the specimens have been so slightly affected during 1000 regulation alternate freezing and thawing tests seems to indicate that the only feasible weathering test will necessarily be an accelerated one.

Sub-Committee VI on Nomenclature prepared a definition for slate which received the favorable vote of Committee D-16 and has been submitted to Committee E-8 of the Society for its suggestions. The definition is as follows:

Slate.—A microgranular crystallin stone derived from argillaceous sediments by regional metamorphism, and characterized by a perfect cleavage quite independent of original bedding, which has been induced by pressure within the earth.

NOTE 1.—The essential mineral constituents are white mica (chiefly sericite) and quartz. Prominent accessory constituents are black mica (biotite), chlorite and hematite. Minor accessory constituents are carbonates, magnetite, apatite, clay, andalusite, barite, rutile, purite, graphite, feldspar, zircon, tourmaline and carbonaceous matter.

NOTE 2.—Igneous slates because of their rare occurrence and insignificant commercial importance are not covered in this definition.

This definition is now recommended by Committee D-16 for publication as tentative. The results of the letter ballot of Committee D-16 on the Proposed Tentative Definition of Slate are as follows: Affirmative 18; negative 0; not voting 3.

The committee recommends that the Tentative Method of Test for Water Absorption of Slate (D 221 - 25 T) and the Tentative Methods of Flexure Testing of Slate (D 222 - 25 T) be continued as tentative without revision.

This report has been submitted to letter ballot of the committee, which consists of 21 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

D. W. KESSLER,
Chairman.

D. KNICKERBACKER BOYD,
Secretary.

EDITORIAL NOTE

The proposed Tentative Definition of the Term Slate, recommended in the report of the committee, was accepted for publication as tentative and appears on page 1001.

REPORT OF COMMITTEE D-17
ON
NAVAL STORES

During the past year, the committee has carried on investigations on the determination of dirt in rosin using two different solvents and on the determination of melting point of rosin by two methods. The committee has also given consideration to methods for the determination of total and of soluble ash, and of water in rosin.

The work on methods for determining dirt while not completed gives promise of yielding an acceptable method for this determination at an early date. The work on the determination of melting point of rosin has not been as satisfactory, and it is felt that much more will have to be done on this subject before the committee will have a method that appears sound and promising. Work on these subjects and also on the determination of total and soluble ash and of water is being actively continued.

The committee held a formal meeting at Cleveland, Ohio, October 22, 1925, at which the work done was fully discussed and that contemplated planned. At this meeting, the committee developed a plan for a symposium on rosin to be held at the annual meeting of the Society for the purpose of bringing out from the users of rosin, (1) the characteristics and qualities that rosin should possess to make it entirely suitable for each of the chief uses, (2) what materials can be employed in place of rosin in these various uses, and also (3) of having producers make clear to the users the conditions and difficulties of making rosin. It is hoped that by these means producers and users of rosin will obtain more definite knowledge of the problems of each class and be brought into closer contact and agreement.[1]

This report has been submitted to letter ballot of the committee, which consists of 17 members, of whom 15 have voted affirmatively, none negatively and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. P. Veitch,
Chairman.

C. F. Speh,
Secretary.

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[1] For the papers and discussion entering into the Symposium on Rosin, see *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, pp. 493–537 (1926).

REPORT OF COMMITTEE E-1

ON

METHODS OF TESTING

Committee E-1 on Methods of Testing has held one meeting during the year, on April 9, 1926. The Advisory Committee held a meeting prior to the meeting of the main committee and one other meeting in December, 1925. The work of the committee has, to a great extent, been concentrated in the sub-committees and these have been quite active. While no new methods are being submitted for publication as tentative, the results of a number of basic studies that have been made are being presented as information and possibly as a guide to those interested in preparing definite methods of test.

The committee has continued the study of methods from a broad viewpoint, as outlined in previous reports, through the several sub-committees and the Editorial Committee of the Advisory Committee. One of the primary purposes in the organization of Committee E-1, in addition to serving to correlate the various methods of test, was to insure the conformity of all test methods with the basic fundamental principles underlying these methods. The sub-committees have been urged to bear this in mind in carrying on their work and that in submitting reports they should submit an analysis dealing with the fundamentals underlying the subject matter of their reports. It should be quite possible to outline the fundamental requirements of at least the principal kinds of test, such as tension, compression, etc. Each specific test as drawn up by the various standing committees could then be checked to see that it conforms to the fundamental requirements for such a test. That the sub-committees have been successful in this, is evidenced by the nature of the reports presented and either abstracted herein or appended *in toto*.

The sub-committees naturally parallel the major groups of tests as set forth in the classification of methods of test published in the report of Committee E-1 for 1924.[1] One new sub-committes has been created during the year, a Sub-Committee on Methods for Density under the chairmanship of Mr. A. T. Goldbeck. This brings the total number of sub-committees up to seven, as follows:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 698 (1924).

Sub-Committee on Mechanical Testing;
Sub-Committee on Impact Testing;
Sub-Committee on Volatility;
Sub-Committee on Plasticity, Consistency, Etc.;
Sub-Committee on Determination of Water;
Sub-Committee on Size and Shape;
Sub-Committee on Methods for Density.

A Sub-Committee on Chemical Composition has been authorized as Committee E-1 has received a request urging that it take in hand the correlation of the various methods of chemical analysis. Shortly after its reorganization in 1920, Committee E-1 deferred consideration of chemical methods, believing that the matter of correlation and review of physical methods was the more urgent. In recent years, the number of methods of chemical analysis included in standards has increased considerably and several different standing committees are involved; there is, therefore, a growing possibility of overlapping in the methods. The scope of the sub-committee, however, will not be confined merely to the usual methods of chemical analysis, but it is intended that it shall study the question of chemical composition from a broad viewpoint, including the methods of radiographic analysis, spectrographic analysis and various phases of physical chemistry. The organization of the sub-committee will be effected as promptly as possible.

From the listing of the several sub-committees of Committee E-1 given above, it is apparent that much of the field of methods of testing—at least that included under the major groupings—is being covered through the sub-committee organization. There are still quite a number of miscellaneous methods of test, however, that do not fall within the scope of any of these sub-committees. In order to provide for the proper study and disposition of these miscellaneous tests, the Editorial Committee of the Advisory Committee, mentioned in last year's report, was organized. As a first step in carrying out the work assigned to it, the Editorial Committee presented five recommendations on the preparation of methods of test in general. These are presented on pages 400–401 of Part I of the Proceedings for 1925. They were subsequently brought to the attention of the individual standing committees. These recommendations tend to crystallize the thoughts and suggestions that Committee E-1 has presented from time to time and are in a sense amplifications of the Regulations Governing the Form but not the Substance of Methods of Test, submitted by Committee E-1 in 1921. That these regulations have been of considerable assistance to the standing committees as a guide in preparing methods of test, is evidenced by the improvement in the form in which the methods are drawn up in recent years, as the review by the Editorial Committee has developed.

The Editorial Committee may function along several lines: (1) It may review the various miscellaneous methods to see that the requirements of the methods are clearly and accurately stated, that no provisions are inconsistent with other methods of the Society, and that the form and arrangement of the methods are in accordance with the Society's requirements as given in the Regulations Governing the Form but not the Substance of Standards; (2) it may make a fundamental study of individual methods of test, calling upon outside experts if need be, and present the results of this study for general information. (3) In addition to making this fundamental study and report a suggested general method of test may be prepared which will serve as a master general method, either to be submitted as a standard of the Society to be referred to by all standing committees having use for the test, or as a method to be used for comparison purposes as a form for the individual standing committees to follow.

The Editorial Committee is functioning in all three ways. As an instance, a study has been made of the methods for refractive index. This investigation has been carried out by Mr. W. H. Fulweiler, a member of the Editorial Committee, and the results are presented in Appendix I to this report. This study includes, first of all, a definition of refractive index and a description and discussion of what refractive index is. Then follows a description of the several types of apparatus employed in its determination and the method of procedure. It includes a statement on how refractive index may be employed and the materials upon which the determination can be made to advantage. A selected bibliography of the more important reference works is appended. Although a study of an apparently simple determination, the report is illustrative of how all methods may be analyzed and of the significant features that may be developed. A similar study is being made by Mr. Fulweiler of the methods of test for solubility in organic solvents.

Similarly, the methods for acidity, saponification number, unsaponifiable matter, iodine number, polymerization, etc., are being studied by Mr. J. P. Hubbell, who is serving on the Editorial Committee for Mr. F. G. Breyer. In carrying on this work Mr. Hubbell has been in communication with a number of experts in the testing of animal, vegetable and mineral oils, and he has received from them comments on the possibility of preparing general methods applicable to a number, if not all of these oils, and of the modifications that may be necessary in any given determination for a particular class of oils. The results of this study will be given at some later time.

The general review of methods has developed the importance of having clear-cut general methods rather than having numerous descriptions of certain determinations (possibly incomplete) appearing in separate standards. For instance, rather than to have a series of tests as applying to a given product all described in one document and then to have the same series of tests, as applying to a second product, appearing as a second complete document, these individual tests could be written up as separate methods of test and referred to wherever applicable, and a short section given in their stead in the individual specifications referring to the general methods for a given determination and setting forth such modifications as might be necessary for a given material. This question was covered in Recommendation 5, appearing in the 1925 Report of Committee E-1, and the committee wishes to reaffirm this recommendation, which reads as follows:

> "5. Instead of numerous descriptions for a certain determination appearing in various standards, have one clear-cut general method complete with definitions and descriptive paragraph, which method could be referred to in the several standards."

It is planned that the Editoral Committee will continue its review of the methods of test and it may be able to make specific recommendations concerning the redrafting of methods along the lines indicated, transmitting its suggestions to the standing committees concerned from time to time throughout the year.

SUB-COMMITTEE ON MECHANICAL TESTING

The Sub-Committee on Mechanical Testing (Mr. H. F. Moore, chairman) has been enlarged in personnel so as to be sufficiently representative to take in hand the consideration of methods of mechanical testing in general. The work of the sub-committee is being divided among a number of sections. For instance, a Section on Tension Testing is being organized under the chairmanship of Mr. R. L. Templin. Similar sections are being organized to cover compression and flexure (transverse) testing. In order that these sections be not too unwieldy, it is planned that a small nucleus group be appointed for each. Each committee of the Society represented on the sub-committee will be given an opportunity to name a representative on each of the sections, these with the appointed group to constitute the voting membership. Advisory membership will be thrown open to any interested member of the Society who should signify to the chairman of the section in question, or to the chairman of the sub-committee, his desire to serve in that capacity.

The section plan of small groups studying a specific type of test has been followed in the appointment of a Section on the Testing of Thin Sheet Metals consisting of Messrs. H. C. Knerr, chairman, H. A. Anderson, R. L. Templin, C. H. Marshall and E. S. Taylerson. This section has been in existence since early in 1925. It has held a number of meetings, some of them partaking of the nature of open forums for the discussion of methods of testing thin sheet material. A report has been presented to the committee and is presented herewith in Appendix II to this report, as information, to elicit comments and suggestions. The committee is not yet prepared to offer any method as a standard of the Society, but its report represents real progress in a field of considerable and of increasing importance. In this same connection, a paper is being presented at this annual meeting by a member of the section, Mr. R. L. Templin, entitled "Effects of Size and Shape of Test Specimen on the Tensile Properties of Sheet Metals."[1]

The Sub-Committee on Mechanical Testing offers the following revisions of the present Tentative Method of Verification of Testing Machines by Means of an Elastic Calibration Bar (E 4 - 24 T).[2] These revisions are being submitted by Committee E-1 with the recommendation that the method, as revised, be continued as tentative:

Section 1—Add a footnote to read as follows:

> "The term 'calibration bar' shall be interpreted to include solid bars, hollow bars, elastic loops, and other members whose elastic deformation can be measured."

Section 5 (*b*).—Insert a note under Section 5 to read as follows:

> "If in taking five or more strainometer readings for any load, the deviation of any one reading is more than 1 per cent from the mean reading, then this series of five or more readings shall be repeated."

Section 6.—Delete the words "shall be permanently attached to the calibration bar," in the first sentence and insert the following:

> "If the strainometer is not permanently attached to the calibration bar, the strainometer shall be removed and replaced for each successive reading taken during the calibration of the bar itself. This, of course, does not mean that the strainometer must be removed for each reading in the regular use of the instrument."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 26, Part II, p. 378 (1926).

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part I, p. 1106 (1924); also 1925 Book of A.S.T.M. Tentative Standards, p. 795.

Section 8.—Change from its present form: namely,

> "The calibration bar shall be used at a temperature between 10 and 32° C. (50 and 90° F.)."

to read as follows:

> "In using a calibration bar made of steel, correction for variation in mean temperature during any calibrations made on different occasions should be made by allowing a diminution of 0.015 per cent ($\frac{15}{1000}$ of 1 per cent) in the modulus of elasticity of steel for each 1° F. increase in temperature. During any calibration with an elastic calibration bar, temperature conditions should be kept as uniform as is possible."

The remaining tentative standards under the jurisdiction of this sub-committee, namely, the Tentative Methods of Tension Testing of Metallic Materials (E 8 – 25 T), Tentative Methods of Compression Testing of Metallic Materials (E 9 – 25 T), Tentative Methods of Brinell Hardness Testing of Metallic Materials (E 10 – 25 T), and the Tentative Definitions of Terms Relating to Methods of Testing (E 6 – 25 T) are to be continued as tentative. The proposed Methods of Torsion Testing and Proposed Methods of Flexure Testing submitted as information last year are receiving further consideration by the sub-committee.

SUB-COMMITTEE ON DETERMINATION OF WATER

The Sub-Committee on Determination of Water, under the chairmanship of Mr. W. H. Fulweiler, has been enlarged both as to scope and personnel so as to give consideration to a study of methods of determination of water in general, instead of confining itself to water in bituminous materials as had heretofore been the case. The sub-committee has not yet had an opportunity to make a detailed study of the various methods.

SUB-COMMITTEE ON SIZE AND SHAPE

Prior to 1925, the Sub-Committee on Size and Shape, under the chairmanship of Mr. F. G. Breyer, for whom Mr. J. P. Hubbell has acted as chairman, was designated a Sub-Committee on Classification of Material According to Size. As such, it had confined its attention exclusively to the methods of mechanical analysis by means of sieves and to the preparation of general specifications for sieves for testing purposes. These specifications were accepted for publication as tentative in 1925 under the title Tentative Specifications for Sieves for Testing Purposes (E 11 – 25 T).[1] They have been brought to the attention of a number of societies with whom the committee had been in touch during the preparation of the specifications. They were also brought to the attention of all standing committees of the Society. No criticisms of the specifications have been received and they are accordingly recommended for advancement to standard.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 850 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 766.

The committee has received considerable encouragement from the standing committees of the ultimate acceptance of the specifications to replace all requirements for sieves now appearing in the standards of the Society. Some industries may prefer to retain, for a time, the arbitrary number designation rather than to employ the new micron designation, giving, however, the micron designation in parentheses.

Since last year, this sub-committee has been completely reorganized. Preparations have been made to start a careful study of methods of measuring the size and shape of particles too fine for ordinary sieve testing. This problem is important to many industries, some of which are: abrasive, cement, lime, linoleum, ore milling, paint, photographic, pigment, powdered coal, and rubber. Much work has been done and many papers published on the subject but there is still no generally accepted method of making such measurements nor are the advantages and limitations of the various methods in use generally recognized and understood.

It is the purpose of this section of the sub-committee to enlist the cooperation of the various investigators now working on this problem with the object of having actual measurements made on samples of different materials distributed by the committee. The results of these first measurements will determine the future program.

The new section includes two classes of members: (1) representatives of other A.S.T.M. committees interested in this work, some of whom are also equipped to actively assist in the work; (2) active cooperators who have agreed to assist by making measurements on samples to be distributed. The present personnel of the new section is as follows:

A.S.T.M. COMMITTEE REPRESENTATIVES

Adv.	F. G. Breyer[1] (*chairman*), New Jersey Zinc Co.
C-1	Louis Anderson, Jr., Alpha Portland Cement Co.;
	L. W. Walter, Erie Railroad Co.
C-7	W. E. Emley,[1] U. S. Bureau of Standards;
	E. E. Eakins,[1] Charles Warner Co.

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[1] Also actively taking part in the work.

C-9	D. A. Abrams,[1] Structural Materials Research Laboratory, Lewis Institute.
D-1	A. G. Belden,[1] National Lead Co.
D-4	F. P. Smith, Dow and Smith; A. N. Johnson, College of Engineering, University of Maryland.
D-5	A. C. Fieldner[1] and W. A. Selvig,[1] Pittsburgh Experiment Station, U. S. Bureau of Mines.
D-9	E. S. Lee, General Electric Co.
E-1	R. E. Hess (*secretary*).

ACTIVE COOPERATORS

Bureau of Standards, L. V. Judson.
Dorr Co., George M. Darby.
Eagle-Picher Lead Co., J. H. Calbeck.
Eastman Kodak Co., S. E. Sheppard.
Fisk Rubber Co., E. W. Fuller.
Goodrich Co., The B. F., James W. Shade.
Goodyear Tire and Rubber Co., W. W. Vogt.
Lehigh Portland Cement Co., J. C. Pearson.
Libbey-Owens Sheet Glass Co., The, Glenn C. Mook.
Pittsburgh Plate Glass Co., P. R. Croll.
Premier Mill Corporation, Byron M. Nester.
School of Public Hygiene, Harvard University, Philip Drinker.
Thermatomic Carbon Co., E. B. Spear.
Vanderbilt Co., Inc., R. T., A. A. Somerville.

A questionnaire was sent to each active cooperator to learn what equipment was available in the different laboratories, what materials were being studied and in what phase of the problem each cooperator was interested. In reply to the questionnaire, 14 replies were received, which indicated that 4 laboratories were most interested in elutriation methods, 6 in microscopic and optical methods, and 4 were interested in both.

Two meetings of the section have been held, one on April 20 at the National Lead Company's laboratory in Brooklyn, and one on April 27 at the New Jersey Zinc Company's laboratory in Palmerton. At the first meeting, methods of separating fine materials into portions containing definite ranges of particle size were discussed and arrangements made for samples to be circulated to the members of the committee interested in this phase of the question, for test. At the second meeting, methods of measuring the average particle size of fine materials were discussed, as well as the meaning of the term "average particle size" and arrangements were made to secure and distribute samples to committee members for particle size measurements.

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[1] Also actively taking part in the work.

SUB-COMMITTEE ON VOLATILITY

The work of the Sub-Committee on Volatility of which Mr. A. W. Dow is chairman, is divided into two parts, namely, a study of the distillation tests and a study of evaporation tests. A report of the sub-committee is appended hereto.

SUB-COMMITTEE ON CONSISTENCY, PLASTICITY, ETC.

The Sub-Committee on Consistency, Plasticity, Etc., under the chairmanship of Mr. W. E. Emley, has been at work for some time on a study of the fundamental concepts of consistency and plasticity, etc. This sub-committee has presented a report which is appended hereto. It is planned that in the light of the principles set forth a study will be made of the individual methods of test of the Society covering determinations for plasticity and consistency.

SUB-COMMITTEE ON IMPACT TESTING

In the belief that there was considerable data and information of value in the published Symposium on Impact Testing held in 1922, an analysis was made by the Sub-Committee on Impact Testing, Mr. E. B. Smith, chairman, of the papers presented as a part of the Symposium. This analysis appears in Appendix III to this report, entitled "Résumé of the Facilities and Methods for Making Impact Tests, and Their Interpretation." This résumé was prepared by the chairman of the sub-committee and gives in summarized form the general conclusions that could be drawn from the statements made in the Symposium.

A proposed recommended procedure for conducting impact tests of metals has been prepared and is appended hereto as Appendix IV, for publication as information. The procedure outlined may serve as a guide in preparing specific methods of impact testing. Comments and suggestions are solicited.

The sub-committee felt that a useful purpose would be served by keeping in touch with the various laboratories conducting impact tests to learn what problems in impact testing are being studied. Such information might be of considerable service to other laboratories contemplating a research program since these laboratories would then know what other laboratories were interested in the same or similar problems. A questionnaire was conducted among the various laboratories in the country and the information secured from these comments has been summarized. This summary is presented in Appendix V of the report.

The recommendations that appear in this report have been submitted to letter ballot with the following results:

Items	Affirmative	Negative	Not Voting
I. ADVANCEMENT TO STANDARD OF TENTATIVE SPECIFICATIONS			
1. Tentative Specifications for Sieves for Testing Purposes (E 11 - 25 T)	25	0	19
II. REVISION OF TENTATIVE METHOD			
2. Tentative Method of Verification of Testing Machines by Means of an Elastic Calibration Bar (E 4 - 24 T)	23	0	21
III. PUBLICATION AS INFORMATION IN REPORT OF E-1			
3. Report of Section on Testing of Thin Sheet Metals	21	0	23
4. Proposed Methods of Impact Testing of Metallic Materials	22	1	21
5. Résumé of the Facilities and Methods for Making Impact Tests and their Interpretation	23	1	20
6. Analysis of Questionnaire on Impact Testing	21	0	23
7. Report of Sub-Committee on Consistency	24	1	19
8. Report of Sub-Committee on Volatility	23	0	21

This report has been submitted to letter ballot of the committee with the following result: Advisory Committee: 6 Affirmative, none negative, 1 not voting; total, 7. Standing Committees: 27 affirmative, none negative, 10 not voting; total, 37.

Respectfully submitted on behalf of the committee,

J. A. CAPP,
Chairman.

R. E. HESS,
Secretary.

EDITORIAL NOTE

The Tentative Specifications for Sieves for Testing Purposes were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1926, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1926.

The proposed revisions of the Tentative Method of Verification of Testing Machines by Means of an Elastic Calibration Bar were accepted. The tentative method as thus revised appears on page 1086.

REPORT OF SUB-COMMITTEE ON VOLATILITY

DISTILLATION TESTS

The Sub-Committee on Volatility has been endeavoring for the part few years to unify the several distillation methods that have been adopted as standard or tentative standard by several of the standing committees. When this sub-committee first took up its work five years ago, Committee D-4 on Road and Paving Materials had a distillation method for road oils and tars employing a 250-cc. flask of the Engler type. Committee D-8 on Bituminous Waterproofing and Roofing Materials adopted the method of Committee D-4 for its work. Committee D-7 on Timber had a distillation method for the analysis of creosote and wood preservative oils, in which the old-fashioned 250-cc. retort was specified. A year or two later, Committee D-2 on Petroleum Products and Lubricants adopted a distillation test for fuel oils and heavy distillates, specifying a flask of the Engler type but slightly larger in dimensions than the D-4 flask. It was the hope of the sub-committee that it could unify the methods of all four of these committees and have them use a flask similar to that which was adopted by Committee D-2. The chances for accomplishing this appeared, at one time, to be very encouraging, especially as several members of Committee D-7 considered the D-2 flask superior to their retort for the distillation method, this opinion having been based on collaborative, comparative work on these two pieces of apparatus by a committee of another society, carried on several years before. It was also found that while Committee D-4 had specified a flask with certain dimensions, these dimensions had been misinterpreted by several instrument dealers and a flask was being sold as a Standard D-4 flask which was in reality of a larger size and corresponded closely to that specified by Committee D-2.

Through the work of the sub-committee, the various committees dealing with distillation tests were encouraged to review their present standard distillation apparatus. Committee D-4, as above mentioned, discovered that many had wrongly interpreted the measurements of the flask specified for distillation and were using one of a larger size. Committee D-7 found that retorts could be manufactured in accord with their specifications which would give different results. This started an investigation by Committee D-7 of a short-necked flask, which was first known as the Carey-Kerr or Church flask but which has recently been called the E-1 flask. This flask is of the shape and dimensions shown in the accompanying Fig. 1.

Committee D-7 has investigated the results obtained with this flask in comparison with the old style retort and has concluded to adopt it in place of the retort. This flask in the meantime has also been adopted by the American Wood Preservers Association and the American Railway Engineering Association for the distillation of creosote. Committee D-4 also investigated this new E-1 flask in comparison with the flask which is now used as standard and the results from the collaborative work favor the new type of flask, and it is more than likely that Committee D-4 will adopt it as its standard flask in place of its present Engler type flask. Collaborative work is still being continued on the E-1 flask for its use in the distillation of cut-back asphalts for road treating. This type of work could not have been carried on satisfactorily with the old Engler type flask which has been the standard of Committee D-4 for several years.

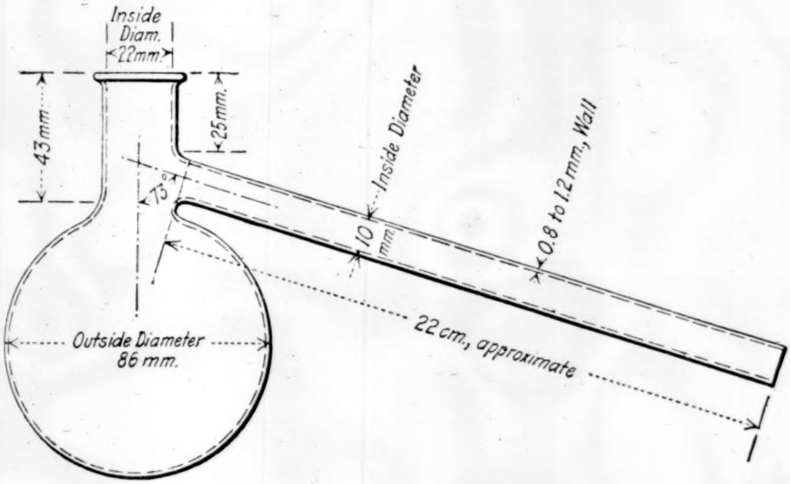

FIG. 1.—Distillation Flask.

Committee D-4 in its description of this new type flask will give its dimensions as follows:

Diameter of bulb (outside)	86 mm.	± 1.5 mm.
Diameter of neck (inside)	22 "	± 1.0 "
Diameter of tubulature (inside)	10.0 "	± 0.5 "
Length of neck	43 "	± 1.0 "
Distance, top of neck to tubulature	25 "	± 1.0 "
Length of tubulature	220 "	± 5.0 "
Angle of tubulature	73 deg.	± 1 deg.

EVAPORATION TESTS

It has been suggested that the Sub-Committee on Volatility review the various methods for loss on heating that have been adopted by the various committees of the Society with a view to seeing if some of these methods could not be unified. The sub-committee has been over all of these methods carefully, and in Table I are listed the various methods for loss on heating with the receptacles used and other factors of the test. It would seem that these methods cannot be unified any further than they are at the present time owing to the fact that they are for testing such a variety of materials and for the purpose of determining such different properties. For example: Method D 6 (Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds) is for the purpose of testing asphalts, cements and heavy road oils to ascertain primarily what hardening effect heat would have on them and whether this hardening is due to loss by volatilization or to oxidation. Methods D 22 (Standard Methods of Laboratory Sampling and Analysis of Coal) and D 37 (Standard Methods of Laboratory Sampling and Analysis of Coke) which are identical, are for the determination of volatile hydrocarbons and other volatile matter in coal and coke. This test is necessarily

TABLE I.—VARIOUS STANDARD AND TENTATIVE METHODS FOR LOSS ON HEATING, SUCH AS DETERMINATION OF MOISTURE OR VOLATILE MATTER

Committee	Serial Number	Material Covered	Receptacle Used as Container of Material Under Test	Quantity Taken for Test	Temperature at which Test is Made	Time and How Heated	Purpose of Test
D-4 on Road and Paving Materials	Method D 6	Oil and Asphalt	Circular tin box, 3-oz. size	50 g.	163° C.	In oven 5 hours	Loss on heating
D-5 on Coal and Coke	Method D 22	Coal	Platinum crucible	1 g.	950° C. ±20° C.	Open flame or muffle 7 minutes	Volatile matter
D-5 on Coal and Coke	Method D 37	Coke	Platinum crucible	1 g.	950° C. ±20° C.	Open flame or muffle 7 minutes	Volatile matter
D-1 on Preservative Coatings	Method D 50	Ferrous Pigments	Porcelain crucible	Not given	High temperature	To constant weight	Loss on ignition
D-9 on Electrical Insulating Materials	Method D 115 T	Insulating Varnish	Dish 75 mm. in diameter	100 cc.	100° F. ±2° F.	7 hours in open room	Loss on heating
D-1 on Preservative Coatings	Method D 124 T	Soya Bean Oil	200-cc. Erlenmeyer flask	10 g.	105–110° C.	30 minutes in oven	Loss on heating
D-1 on Preservative Coatings	Method D 125	Perilla Oil	200-cc. Erlenmeyer flask	10 g.	105–110° C.	30 minutes in oven	Loss on heating
D-1 on Preservative Coatings	Method D 126	Chromium Pigments	Crucible	Not given	Low red heat	Open flame 2 hours	Carbon and volatile matter
D-8 on Bituminous Waterproofing and Roofing Materials	Method D 146 T	Fabric Saturated with Bitumen		Strip of material 12 by 6 in.	105° C. ±3° C.	In oven 5 hours	Loss on heating
D-1 on Preservative Coatings	Method D 154	Oleo-resinous Varnishes	Shallow metal dish 8 cm. in diameter	1.5 g.	105–110° C.	3 hours in oven	Non-volatile matter

carried on at a high temperature in a platinum crucible. Methods D 50 (Standard Methods of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese) and D 126 (Standard Methods of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green) are for the determination of volatile matter in pigments at a low red heat. This volatile matter may consist of combined water, CO_2, and in some cases SO_3. The methods appearing in Specifications D 124 T and D 125 are identical and are for the determination of the loss on heating of soya-bean oil and perilla oil. It is necessary to conduct this test in a closed flask in an atmosphere of CO_2 so as to prevent the absorption of oxygen by the oils. Method D 115 T for loss on heating at 100° F. on insulating varnishes, appears to be for a test that is not required on any of the other materials listed. Methods D 146 T (Tentative Methods of Testing Felted and Woven Fabrics for Use in Waterproofing and Roofing) are for loss on heating on strips of felt or like material that have been saturated with bitumen. This is totally different from any other material listed. Method D 154 is for the determination of non-volatile matter in varnish. This method will also be found under Methods D 115 T (Insulating Varnish) for the same purpose and is a different determination from any listed above.

It will be noted that where the determinations are on similar materials the methods are alike, as for instance:

> In the determination of volatile matter in coal and coke, Methods D 22 and D 37;
>
> Methods in Specifications D 124 T and D 125 are also the same for the loss on heating of soya bean oil and perilla oil;
>
> Methods D 50 and D 126, which are both made for volatile matter in pigments of different kinds might be so written as to be in accord with each other. The method of examination, however, is so superficially described in both of these tests that it would rather indicate that the determination was of little or no importance in the examination of these pigments. It might be that Committee D-1 on Preservative Coatings for Structural Materials, the committee having jurisdiction over these methods, would review these two tests and, if possible, rewrite them so as to conform with each other.

Respectfully submitted on behalf of the sub-committee,

A. W. DOW,
Chairman.

REPORT OF SUB-COMMITTEE ON CONSISTENCY, PLASTICITY, ETC.

After some years of effort, the sub-committee has finally arrived at the conclusion that the difference in the meanings of the terms "consistency" "plasticity," etc., as used by various industries are apparent rather than real. The sub-committee has crystallized a fundamental conception, from which the meanings used by all of the industries can be derived, and it can therefore be shown that these meanings are all fundamentally similar.

Going back to the very beginning, we may start with the premise that when a load is applied to a body the deformation of the body will vary with the magnitude of the load. To deny this premise would be to assert the existence of a perfectly rigid body. This relation between load and deformation holds without exception, for liquids, gases, or solids, for plastic, elastic, or viscous materials.

The broad general terms "load" and "deformation" have been used intentionally because any more specific term would limit the discussion to a specific method of measurement. It takes but little imagination to see that in a viscosimeter the load is the head of oil in the instrument and the deformation is the quantity of oil which flows out; that the bumping of the flow table for concrete is merely a device for increasing the load, etc.

The work of Bingham and Green has demonstrated the essential difference between the two cases; wherein the deformation is or is not directly proportional to the load.

Taking the simpler case first, when the deformation is directly proportional to the load, the body is either viscous or elastic, depending upon whether the deformation is permanent or not. Since the proportionality is direct, the results can be expressed by a single figure, and therefore the difficulties encountered in measuring viscosity are of a mechanical and not a theoretical nature.

When the deformation is not directly proportional to the load, the straight part of the line indicating the relation between the two will not pass through the origin. If the body is plastic then, to use Bingham and Green's nomenclature, the slope of the line represents the mobility, and the yield value is the distance of the load intercept from the origin. The importance of this conception lies in the fact that while viscosity can be expressed by one figure (the slope of the line), plasticity requires two figures—the slope of the line and its position.

The yield value is commonly taken to represent the load which can be applied to a plastic body without causing any deformation. Theoretically, of course, this definition does not hold unless we admit that the plastic body is perfectly rigid under small loads. It would seem more logical to assume that plastic bodies are elastic under loads less than the yield value, in which case plastic bodies would differ from other solids only in the relative magnitudes of their elastic limits.

In many industries, use is made of natural or artificial mixtures of solids and liquids. To determine whether or not such a mixture has been proportioned properly for the purpose in view, it has become customary to measure the deformation produced by a standard load or the load required to produce a standard deformation. In other words, one point on the load-deformation line is determined, which, of course, is not sufficient to fix either the slope or position of the line. It probably would not be difficult to use the same apparatus to determine a second point on the line. This would permit a decision to be reached as to whether the mixture is viscous or plastic.

If the mixture is found to be viscous, the data will permit direct comparison between the viscosity of the mixtures in question and that of any other viscous mixture. But if the mixture is found to be plastic, no such direct comparison can be made. Let us assume, for instance, that two mixtures differ from each other as to both yield value and mobility, but give exactly the same deformation with the same load. Which is the more plastic? The answer to this question can be reached through a study of the use to which the material is to be put. If the use demands high yield value and low mobility, one mixture may be the better; if the requirements are reversed, the other mixture may be the better. This explains why the clay and lime industries, for example, have held such diametrically opposite views on plasticity.

It was stated above that direct comparisons between plastic mixtures cannot be made. Theoretically this is so, but practically approximate comparisons can be made under certain conditions. If the materials considered are similar, as two brands of the same produce, it may be assumed that the relationship between their yield values and mobilities will be practically the same. If, in addition, they are to be used for the same purpose, so that the requirements as to yield value and mobility are the same, then a conclusion can be reached that one is more plastic than the other.

The industries are interested chiefly in this latter proposition—the comparison of similar materials as to their suitability for a given purpose. They have customarily simplified the matter still more by limiting the measurements to the fixing of one point on the line, which gives them the necessary information as to the relative proportions of liquid and solid in the mixture. Obviously, the industries making use of such measurements neither know nor care whether they are measuring viscosity or plasticity, and, to avoid possible confusion, the term "consistency" has generally been adopted as the name for this property.

The various slump tests as applied to lime mortar, concrete, gypsum, etc., are devices for measuring the deformation produced by a given load, gravity. Sometimes the effective load is increased by bumping the specimen, as in the flow table for concrete and some of the more recent designs of equipment for testing gypsum. As used, they measure consistency. It should be easily possible to measure the deformation caused by a second standard load. With two points on the line, it could then be decided whether the material is plastic or viscous, and the results could then be expressed by the more definite terms, "plasticity" or "viscosity," as the case might be.

The penetration method, such as the Vicat or Gilmore needle and the similar tests devised for magnesite and bituminous materials, are obviously in the same category as the above.

Methods which measure the rate of flow of materials through an orifice may be considered as different applications of the above principle. Since the materials tested with viscosimeters are, however, usually known to be viscous, it is generally better to express the results as viscosity rather than to use the less definite term, "consistency."

Other methods in use, such as the "plasticity" test for hydrated lime and the float test for creosote oil residues, really measure the rate of change of consistency when the material is subjected to the action of some extraneous factor (water absorption, and temperature change in the two cases mentioned).

It is hoped that the above discussion will lead those interested to make the necessary changes in their test methods, so that they can measure plasticity or viscosity, rather than consistency. All that is involved, is to determine the amounts of deformation caused by the application of at least two loads, instead of using only one as at present. The information thus gained may not have immediate practical application, but will add much to our general knowledge of the properties of materials.

Respectfully submitted on behalf of the sub-committee,

WARREN E. EMLEY,
Chairman.

APPENDIX I

INDEX OF REFRACTION

Refractive index is the ratio of the velocities of light in two consecutive media. Light travels fastest in vacuo, but in space partially occupied by matter the velocity is generally diminished. Thus, when light passes from a vacuum into an optically denser medium its velocity is lessened and the ray bent at the surface of contact between the two media.

It has been found that the ratio between the sines of the angles of incidence and refraction is a constant, and is equal to the ratio of the velocities of light in the two media. The equation may be written

$$\frac{\text{Sin } i}{\text{Sin } r} = \frac{V_1}{V_2} = n$$

whree n denotes the index of refraction.

If we take the case where the light passes from a vacuum into a denser medium, n is then called the absolute refractive index. If light passes from one medium to another, n expresses the refractive index relative to the first and if the first is air, as is usually the practice, n is known as the ordinary refractive index.

The velocity of light through a substance depends on its wave length. Thus, rays of light, having different wave lengths, entering some medium at the same angle of incidence will emerge at various angles of refraction depending on the wave length of the ray. This property of matter is known as dispersion. It is clear that in order to obtain comparable values the refractive indices of substances must be measured with light of some standard wave length.

The wave lengths commonly employed are:

Red H (C)	= 6563	Ångström units
Yellow Na (D)	= 5893	" "
Blue H (F)	= 4861	" "
Blue H (G_1)	= 4340	" "

For routine work, the H line and the Na line are the most frequently used. The difference between the refractive index of a substance for the Hα and Hδ lines is known as the degree of dispersion. Moreover, the degree of dispersion is a characteristic of the medium studied and is different for different media. In many cases the variation in the dispersion gives more information than the absolute value of the refractive index.

METHOD AND APPARATUS

The simplest form of apparatus for the determination of the refractive index would be a spectrometer in which light from say a hydrogen tube is passed through a collimator, then through a prism of the material under examination and the angle of minimum deviation determined by means of a telescope provided with cross hairs mounted on a graduated circle. When the prism is set so that the light of a given wave length suffers the minimum deviation, it is possible to show that $N = \frac{\text{Sin } \frac{1}{2}(D+A)}{\text{Sin } \frac{1}{2} A}$. Such a method is, of course, readily applicable to solids, but in this case, the solid must be constructed in the form of a prism. In the case of liquids, it is possible to place these in a hollow prism, the sides of which are closed with optically flat glass.

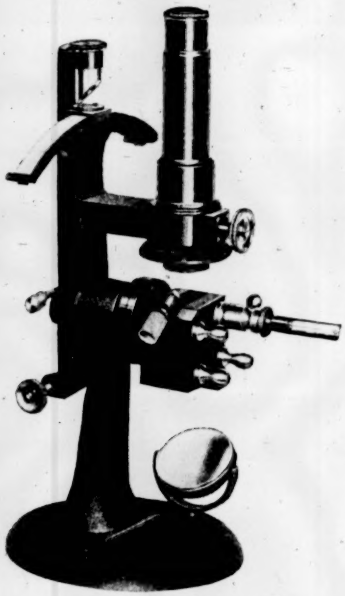

FIG. 1.—Abbé Refractometer.

This method, while generally applicable, requires a considerable amount of a liquid for examination and a number of types of apparatus for laboratory work have been evolved which enable the readings to be made with greater facility. Among these may be mentioned the Abbé form of refractometer which permits the determination of the refractive index for the *D* line to be made with ordinary white light. This instrument is illustrated in Fig. 1 and required only a few drops of the material, which is placed between the faces of a water-cooled prismatic optical system. Such apparatus usually reads between a refractive index 1.3 to 1.7. The scale is divided to the third place of decimals and the fourth place can be estimated. An approximate determination of the dispersion can be obtained from the readings of the position of the compensator when the dividing line of the field is colorless, by reference to tables supplied with the instrument.

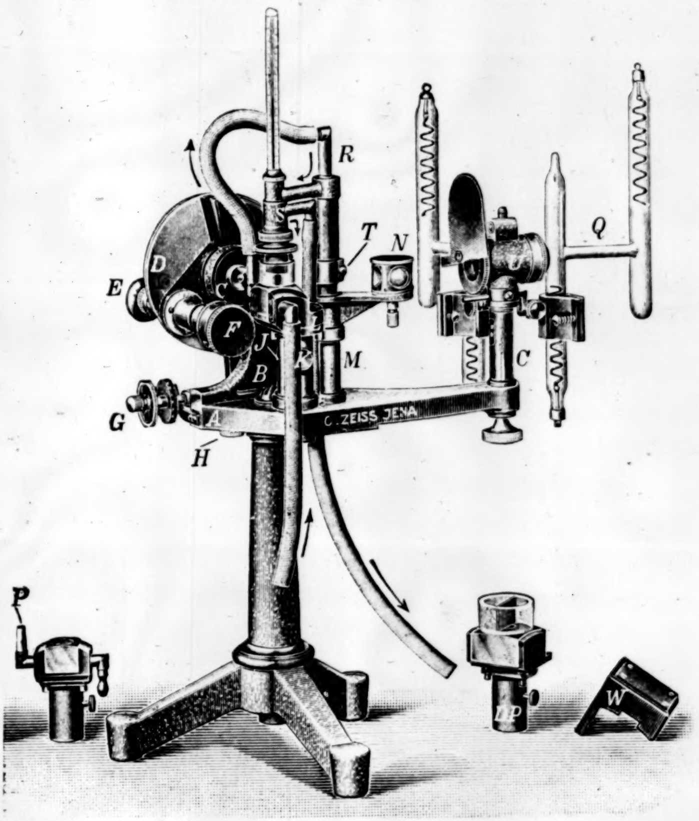

FIG. 2.—Pulfrich Refractometer.

The Abbé instrument is the type generally used in commercial laboratories and is the form recommended in our present specifications.

For more precise work, the Pulfrich refractometer which is illustrated in Fig. 2 permits the determination of the refractive index to possibly five places of decimals, giving an accurate figure to four and permits the determination of dispersion to about two points in the fifth place. In this apparatus, a glass prism of high refractive index has two plane polished faces which are perpendicular to one another, and is so placed that one of these is vertical and the other horizontal. The substance whose refractive index is required is placed upon the horizontal surface, and in the case of a liquid is contained in a glass cell cemented to the prism so as to contain that face.

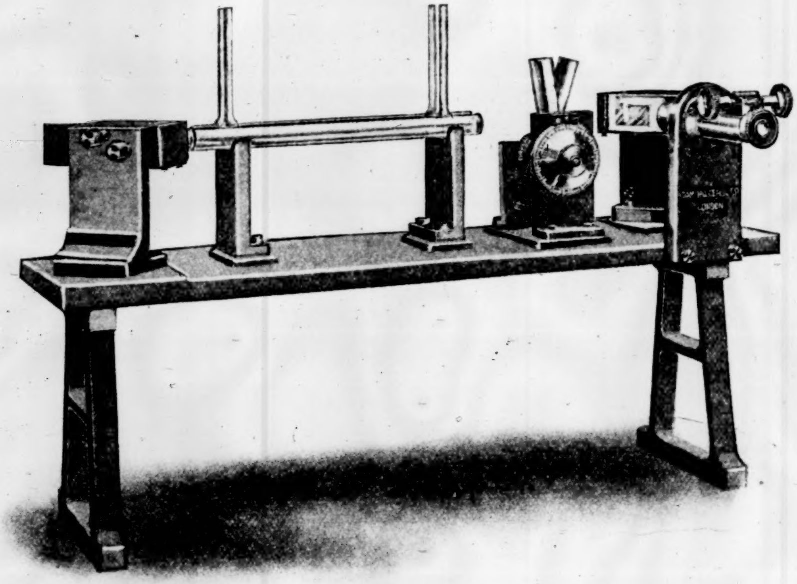

FIG. 3.—Jamin Refractometer.

A beam of monochromatic light is directed horizontally through the substance so that it meets the prism face at grazing incidence. The emergent beam is bounded sharply by that ray which actually grazes the prism surface, and the sharp boundary is observed with a telescope attached to a divided circle. On this circle, whose axis of rotation is horizontal, the angle of emergence of the beam from the vertical prism face can be read to one minute with the aid of a vernier. For making measurements of dispersion, a clamp and micrometer screw are provided, the smallest division on the drum head of the micrometer screw corresponding to six seconds of arc. A condensing lens and supporting rod for the vacuum tube form part of the apparatus. With the Pul-

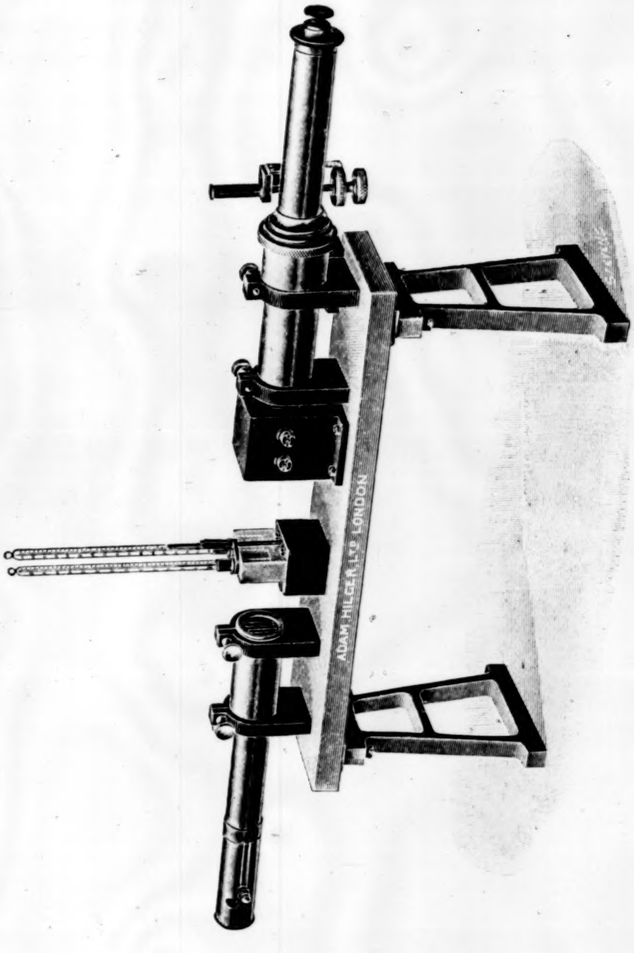
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FIG. 4.—Rayleigh Refractometer.

frich instrument, the refractive index for a number of wave lengths can be readily determined and the dispersion curve constructed.

Where a very high degree of accuracy is required, instruments based on the interference principle may be used. In these instruments, however, the refractive index of the sample under examination is compared with a standard. Due to the extreme delicacy of these methods, very small variations in refractive index can be measured. Among such instruments may be mentioned the Jamin which is illustrated in Fig. 3 and the Rayleigh which is illustrated in Fig. 4. With the Rayleigh refractometer as used for gases, the refractive index may be measured to about one part in 20,000, which would correspond to about two points in the eighth decimal place. For liquids, the instrument has a range of about eight points in the third place with about the same order of precision.

For the determination of refractive index at wave lengths in the ultra violet, special types of apparatus must be used. The use of the refractive index in ultra violet light has not as yet been applied in specifications, so this phase of the subject will not be considered here.

Microscopic methods are also available for the approximate determination of the refractive index.

The refractive index also varies considerably with the density of the substance. There are two formulas now in general use which connect the refractive index with the density of the material. They are the Gladstone and Dale formula:

$$\frac{n-1}{d} = R = \text{a constant;}$$

and the Lorentz and Lorenz:

$$\frac{n^2-1}{n^2+2}\,\frac{1}{d} = r = \text{a constant.}$$

R in both cases is called the "specific refractive power" where n is the refractive index and d the density of the substance. The product of the specific refractive power and the molecular weight of the substance is called the "molecular refractive power":

Gladstone and Dale.—

$$(n-1)\,\frac{m}{d} = M = \text{Molecular refractive power.}$$

Lorentz-Lorenz.—

$$\frac{n^2-1}{n^2+2}\cdot\frac{m}{d} = M = \text{Molecular refractive power.}$$

Early investigators attempted to show that the refractivity of a compound was equal to the sum of the refractivities of its several components. This appeared to be true but was later disproved when measurements were made with greater precision. It was found that the refractivity of a substance was not alone due to the elements constituting its structure but also the manner in which they were related to each other, such as relative positions, attraction for each other, etc. In other words, the refractivity of a compound is due to both additive and constitutive properties.

As a result of a great deal of experimental work it is evident that the refractive index coupled with the specific and molecular refractivities is characteristic for any compound. Working on this basis, many investigators have calculated the specific refractivity of the elements, hydrogen, oxygen, carbon and the halogens. These refractivities depend on the type of linkage under which each atom exists. For example, the refractivity of oxygen depends on whether it exists in a hydroxyl, ethereal or ketonic state.

The following table gives the data by which the molecular refractive power of a compound may be calculated from its known constitution.

ELEMENT	n FORMULA		n^2 FORMULA	
	R_α	R_D	r_α	r_D
Carbon singly bound occurring alone, C°	5.00	4.71	2.365	2.592
Carbon singly bound, C′				2.501
Hydrogen, H	1.30	1.47	1.103	1.051
Hydroxyl oxygen, O′	2.80	2.65	1.506	1.521
Ethereal oxygen, O			1.655	1.683
Ketonic oxygen, O″	3.40	3.33	2.328	2.287
Ethenoid linkage, I	2.40	2.64	1.836	1.707
Acetylene linkage, I	....	....	2.27 or 2.48	2.10
Chlorine	9.79	10.05	6.014	5.998
Bromine	15.38	15.34	8.863	8.927
Iodine	24.87	25.01	13.808	14.12
Sulfur, S	....	....	8.0	....

GROUP	M_a	GROUP	M_a
$-CH_2-$	7.754	$-CO-$	8.07
$-CH_3$	8.81	$-CONH_2$	16.06
$-C_6H_5$	43.62	$-CH=NOH$	17.25
$-COOH$	12.15	$-NH_2$	7.41
$-COOC_2H_5$	27.33	$-OH$	4.30
$-COOCH_3$	19.58	$-OC_6H_5$	47.19
$-COCH_3$	17.20	$-CN$	9.07
$-Br$	14.92	$-I$	24.56

In the foregoing discussion, it has been assumed that the determination of the refractive index has been made at standard temperatures since the refractive index varies slightly with change in temperature; the molecular refraction, however, since it contains the density term, is only slightly affected. One of the arguments for the use of the Lorentz-Lorenz or n^2 formula is the fact that it is affected to a smaller degree by change of state and temperature.

The temperature change for 1° C.

for the *D* line for water is	0.000109
for vegetable oils	0.000365
for benzene	0.000665

The variation in the value of the temperature coefficient makes it necessary that the determination should be made at accurately controlled temperatures known to 0.1° C.

As a standardizing substance, water is quite suitable as it has a small temperature coefficient and the following values may be used: for the *D* line of sodium:

$$
\begin{aligned}
N_D\ 20^\circ\ \text{C.} &= 1.33299 \\
25^\circ\ \text{C.} &= 1.33248 \\
30^\circ\ \text{C.} &= 1.33190
\end{aligned}
$$

It is evident from the foregoing discussion that the refractive index of a chemical compound is a very characteristic property of the substances and is frequently used in identification as the determination can be made in a very few minutes and requires with suitable apparatus only a few drops of the material.

The use of the refractive index is not confined to organic compounds but may be appended to aqueous solutions as well and may serve as a very rapid and accurate method for determining the composition of solutions of known materials. Some references to the use of the refractive index is given in the bibliography appended hereto.

In the work of the Society, the refractive index has been used as a criterion of purity in the following specifications.

Specification D 1 – 15 for Raw Linseed Oil from North American Seed.

Specification D 11 – 15 for Boiled Linseed Oil from North American Seed.

Specification D 12 – 25 T for Raw Tung Oil.

Specification D 13 – 24 for Turpentine.

Specification D 125 – 23 for Perilla Oil, Raw or Refined.

In all of the above specifications the use of the Abbé type instrument at 25° C. is recommended. It would seem desirable to add that the index is determined for the *D* line, in case other instruments are used, and that attention should be called to the necessity for accurate temperature control.

In view of the fact that the refractive index of a substance is a fundamental constant and can be very quickly and accurately determined, especially in the case of liquids, it would seem that this constant might be used more frequently in the future in our specifications.

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APPENDIX II

REPORT ON TESTING OF THIN SHEET METALS

About April, 1925, a Section, of the Sub-Committee on Mechanical Testing of Committee E-1, was appointed by the chairman, H. F. Moore, to report on methods for testing of thin sheet metals, since it was recognized that the present standards of the Society are inadequate. This section has held meetings at Atlantic City in June, 1925, Philadelphia in January, 1926, Providence in March, 1926, and Philadelphia in April, 1926.

The term "thin sheet metals" has been interpreted by the section to include wrought ferrous and non-ferrous metals in the form of plate, sheet, flat wire, strip, band, and hoop, without respect to width, length, grade or method of manufacture, in thicknesses from 0.010 to 0.250 in., inclusive.

Procedure.—The most urgent problem in the testing of thin sheet metals is considered to be the development of suitable and uniform means for tension testing, including requirements for the specimens and methods of test. Methods of test and test results are influenced by the form and dimensions of the test specimen, which is therefore the primary factor. It was accordingly decided to concentrate on this phase of the subject and the problem was approached along the following lines:

I. An analytical study of factors determining the ideal test specimen.
II. A survey of specimens now in use.
III. An experimental study of the effect of certain variations in size and form of specimen.
IV. Recommendation of a tentative specimen.

Object.—The object of this report is to summarize the work of the section to date for the purpose of information and discussion.

I. ANALYTICAL STUDY OF SPECIMEN FACTORS[1]

The factors of thickness, dimensions of specimen, and of specimen blank enter into the determination of a tension test specimen for thin sheet metals. The thickness of the specimen is determined by that of the material, and should represent the full (original) thickness thereof.

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[1] This section of the report represents the views of the members of the section, based upon personal experience, published experimental data and discussion and suggestions received from those interested in the work.

It would be desirable to develop, if possible, a single specimen for the range of thicknesses above mentioned, for the following reasons:

1. To facilitate cutting of specimen blanks to a standard size.
2. To facilitate machining specimens of various thicknesses simultaneously.
3. To permit standardization of testing equipment, including gage markers, extensometers, testing machines and grips.
4. To simplify computation, recording and comparison of test data.
5. To facilitate testing, handling and storage of specimens.

These practical advantages are believed to outweigh any theoretical advantages that might be gained by varying the dimensions of the test specimen, as a function of the thickness of the material. It is recognized that the ratio of thickness to the dimensions of the gage section has an important influence on the test results, expecially the elongation, but it is believed that such variations should, and readily can, be taken care of by appropriate provisions in the specifications.

It is not the function of a test specimen, or method of test, for use in acceptance tests under specifications, to produce the highest possible numerical values in the properties measured; nor is it, necessarily, to serve as a means of studying the properties of materials for research or other special purposes. It is, rather, to afford a means for readily obtaining, in different laboratories and at different times, values for specific properties, which are directly comparable.

The results obtained in nearly all mechanical tests are necessarily more or less empirical, and are influenced by the form of the test specimen as well as the method of making the test. While the methods and specimens used in acceptance tests should be such as to afford the maximum amount of information regarding the characteristics of the material, this should not be carried to the point of sacrificing simplicity, practicability and uniformity of practice.

Dimensional factors in a tension specimen for sheet metal are indicated in the development diagram, Fig. 1, and will be discussed in the order shown. The fundamental dimensions are those of gage length and gage width.

A. Gage Length.—There are many advantages in the use of a comparatively short gage length, for example:

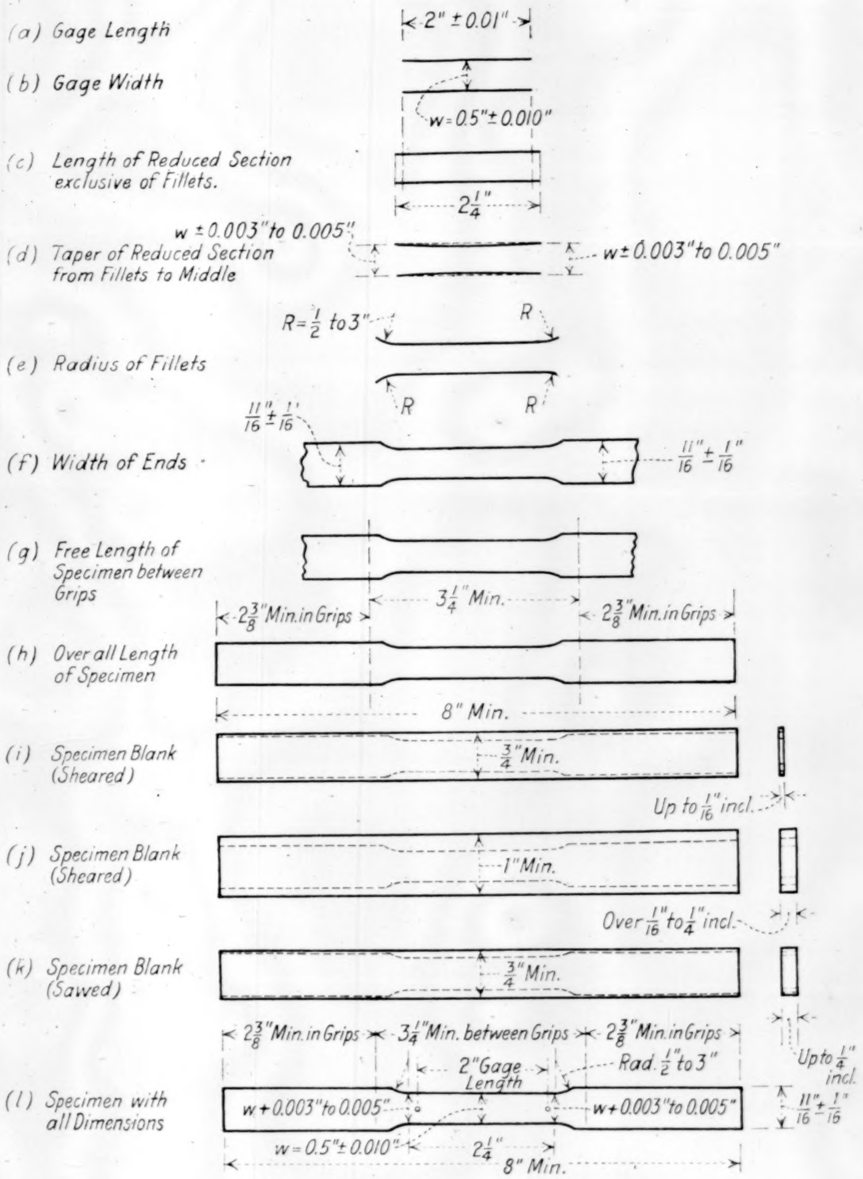
(a) Gage Length
2" ± 0.01"
(b) Gage Width
w = 0.5" ± 0.010"
(c) Length of Reduced Section exclusive of Fillets.
2 1/4"
(d) Taper of Reduced Section from Fillets to Middle
w ± 0.003" to 0.005"
w ± 0.003" to 0.005"
R = 1/2 to 3"
R
(e) Radius of Fillets
R
R
11/16" ± 1/16"
(f) Width of Ends
11/16" ± 1/16"
(g) Free Length of Specimen between Grips
2 3/8" Min. in Grips
3 1/4" Min.
2 3/8" Min. in Grips
(h) Over all Length of Specimen
8" Min.
(i) Specimen Blank (Sheared)
3/4" Min.
Up to 1/16" incl.
(j) Specimen Blank (Sheared)
1" Min.
Over 1/16" to 1/4" incl.
(k) Specimen Blank (Sawed)
3/4" Min.
Up to 1/4" incl.
2 3/8" Min. in Grips
3 1/4" Min. between Grips
2 3/8" Min. in Grips
2" Gage Length
Rad. 1/2" to 3"
(l) Specimen with all Dimensions
w + 0.003" to 0.005"
w + 0.003" to 0.005"
11/16" ± 1/16"
w = 0.5" ± 0.010"
2 1/4"
8" Min.

FIG. 1.—The Development of a Tension Test Specimen for Thin Sheet Metal.

1. Greater availability of material, particularly for transverse specimens from material of moderate width.
2. Economy of material required for test purposes.
3. Minimum difficulty in machining.

In contrast to the above advantages of a short gage length there may be cited in favor of a longer gage length, greater accuracy in stress-strain measurements. It has also been suggested that the use of a longer gage length gives information which may be used as an index to certain other useful properties of the material, for example, the drawing qualities. Up to the present time, the section has been unable to obtain experimental verification of this idea. It was thought that such properties may be more definitely determined in other ways. Moreover, it was considered undesirable to burden all industry with the disadvantages incident to a longer gage length for the sake of a few who may require a long specimen for the determination of certain special properties.

The 2-in. gage length at present extensively used for tension tests of metals in various other forms appears equally suitable for use in the testing of thin sheets. The adoption of this same gage length for thin sheet metals would have many practical advantages.

B. Gage Width.—General agreement was reached on the desirability of a $\frac{1}{2}$-in. gage width, for the following reasons:

1. More uniform distribution of stress during testing than in a wider specimen, especially for very thin sheets, minimizing the tearing effect characteristic of the latter.
2. Greater availability, from narrow materials, as compared to wider specimens.
3. Economy of material, as compared to wider specimens.
4. Greater ease of preparation, handling and testing, as compared to narrower specimens.

A tolerance of ±2 per cent (±0.010 in.) was considered desirable from a standpoint of practicability of machining, and sufficiently close for test purposes. It is essential that the actual width and thickness of test specimens be measured before testing rather than to depend upon their being machined accurately to nominal dimensions.

C. Length of Reduced Section.—The length of the reduced section, exclusive of fillets, should be at least $2\frac{1}{4}$ in., this being the shortest length which will satisfactorily allow for certain variations in machining and avoid serious non-uniform stress distribution within the gage length due to shoulder effects.

D. Taper of Reduced Section.—A taper of 0.003 to 0.005 in. in width from the fillets to the middle of the reduced section is considered desirable to assist in obtaining fractures in the middle third of the gage length. This will also tend to offset the effects of gage marks, slight variations in thickness and width, and stress concentrations due to shoulder effects.

E. Radius of Fillets.—To minimize stress concentrations at shoulders, the radius of fillets should be at least ½ in. and preferably between ½ and 3 in.

F. Width of Ends.—It seems desirable that the width of ends of the specimen be $\frac{11}{16} \pm \frac{1}{16}$ in. This gives sufficient latitude to permit the use of narrow ends having a minimum shoulder effect,[1,2,3] or of wide ends requiring a minimum amount of machining.

NOTE.—The straight-sided specimen (without enlarged ends) eliminates the shoulder effect, and is advocated by some laboratories on the ground of simplicity in preparation. To prevent fracture outside the gage length in testing such a specimen requires special precautions which are probably beyond the resources of the average laboratory. Moreover, if the specimen is sheared, errors are likely to result unless the strained material is removed by machining, necessitating about as much machining as with specimens having shouldered ends.

G. Free Length of Specimen.—In order to avoid stress concentrations in the reduced section and in the fillet portion, due to the effects of the grips, the minimum free length of the specimen between grips should be 3¼ in.

H. Overall Length of Specimen.—A minimum overall length of 8 in. is considered essential in order to provide sufficient material for gripping. This gives 2⅜ in. in the grips, which is probably adequate for all types of material when proper gripping facilities are provided.

I. Specimen Blank.—When the blank is sheared, its minimum width should be ¾ in. for material up to $\frac{1}{16}$ in. inclusive, and 1 in. for thicknesses greater than $\frac{1}{16}$ in., to permit the removal of sufficient material from each edge to substantially eliminate from the reduced section the effects of shearing. The specimen should be machined from approximately the center of the blank.

When the blank is sawed, or otherwise machined without producing severe distortion in the material, the minimum width may be ¾ in. for all thicknesses. It is good practice to machine the entire length of at least one edge of specimens to provide proper alignment in the preparation of the gage section, as well as in gripping.

J. Finished Specimen.—The specimen resulting from the foregoing process of development is shown in Fig. 1 (*l*).

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[1] E. G. Coker, "Tension Tests of Materials," *Engineering* (London), January 7, 1921, Vol. CXI, p. 1.

[2] H. A. Anderson, "Tension Tests of Thin Gage Metals and Light Alloys," *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 990 (1924).

[3] N. S. Otey, "Testing Metals for Aircraft," *The Iron Age*, December 17, 1925, p. 1660.

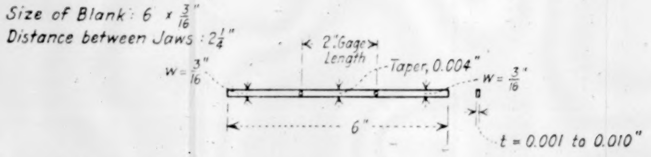
Size of Blank: 6 x 3/16"
Distance between Jaws: 2 1/4"
2" Gage Length
w = 3/16"
Taper, 0.004"
w = 3/16"
6"
t = 0.001 to 0.010"

FIG. 2.—Tension Test Specimen for Hard and Soft Non-Ferrous Sheets, American Brass Co.

Specimen blank sheared. Very sharp slitting rolls used.

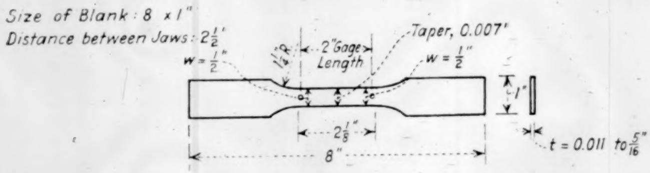
Size of Blank: 8 x 1"
Distance between Jaws: 2 1/2"
w = 1/2"
1/2" R
2" Gage Length
Taper, 0.007"
w = 1/2"
1"
2 1/8"
8"
t = 0.011 to 5/16"

FIG. 3.—Tension Test Specimen for Hard and Soft Non-Ferrous Sheets, American Brass Co.

Specimen blank sawed or sheared.

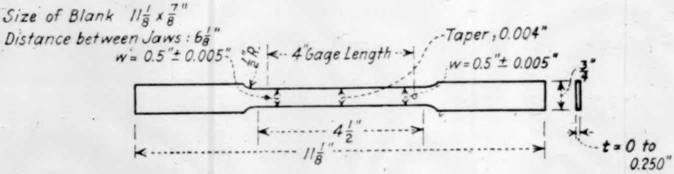
Size of Blank 11 1/8 x 7/8"
Distance between Jaws: 6 1/8"
w = 0.5" ± 0.005"
1/4" R
4" Gage Length
Taper, 0.004"
w = 0.5" ± 0.005"
3/4"
4 1/2"
11 1/8"
t = 0 to 0.250"

FIG. 4.—Tension Test Specimen for All Sheet Metals, Engineering Division, U. S. Army Air Service, Physical Testing Branch, McCook Field, Dayton, Ohio.

Elongation quoted on 2 in. Special specimen used for modulus determination.

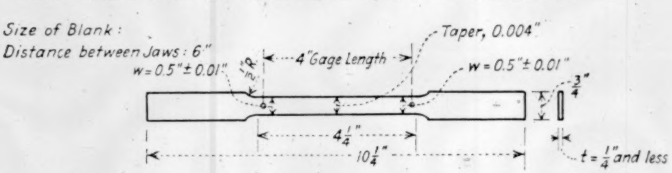
Size of Blank:
Distance between Jaws: 6"
w = 0.5" ± 0.01"
1/4" R
4" Gage Length
Taper, 0.004"
w = 0.5" ± 0.01"
3/4"
4 1/4"
10 1/4"
t = 1/4" and less

FIG. 5.—Tension Test Specimen for Sheet Metals, Naval Aircraft Factory (Specification G1A) Philadelphia, Pa.

In testing thin sheet, tearing can be reduced by making width of ends equal to 1.13 times gage width.

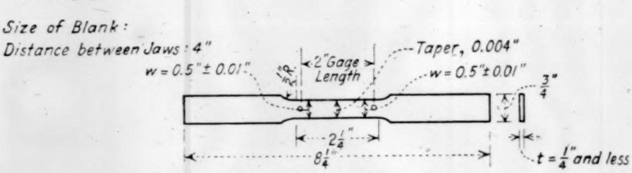
Size of Blank:
Distance between Jaws: 4"
w = 0.5" ± 0.01"
1/4" R
2" Gage Length
Taper, 0.004"
w = 0.5" ± 0.01"
3/4"
2 1/4"
8 1/4"
t = 1/4" and less

FIG. 6.—Tension Test Specimen for Sheet Metals, Naval Aircraft Factory (Specification G1A) Philadelphia, Pa.

In testing thin sheet, tearing can be reduced by making width of ends equal to 1.13 times gage width.

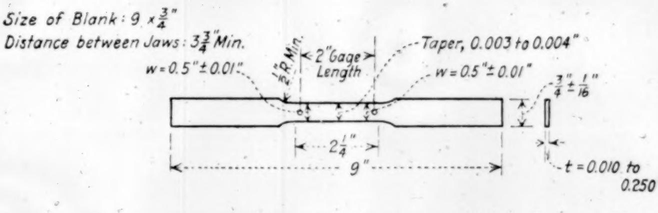
Size of Blank: 9 × 3/4"
Distance between Jaws: 3 3/4" Min.
1/2" R. Min.
2" Gage Length
Taper, 0.003 to 0.004"
w = 0.5" ± 0.01"
w = 0.5" ± 0.01"
3/4" ± 1/16"
2 1/4"
9"
t = 0.010 to 0.250"

FIG. 7.—Tension Test Specimen for Ferrous and Non-Ferrous Sheet Metals and Aluminum Sheet, Aluminum Co. of America, and War Department, Watertown Arsenal.

Blank sheared up to 1/16 in. Thicker sheet sawed. This type of specimen also standard with the Ordnance Department.

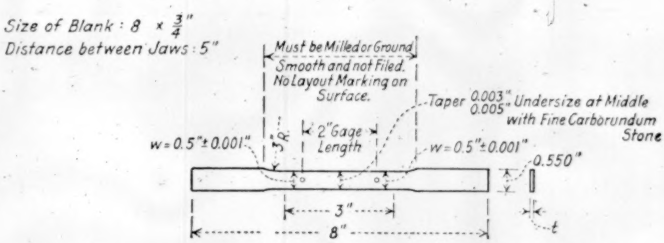
Size of Blank: 8 × 3/4"
Distance between Jaws: 5"
Must be Milled or Ground Smooth and not Filed. No Layout Marking on Surface.
Taper 0.003" 0.005" Undersize at Middle with Fine Carborundum Stone
3" R.
2" Gage Length
w = 0.5" ± 0.001"
w = 0.5" ± 0.001"
0.550"
3"
8"
t

FIG. 8.—Tension Test Specimen for Ferrous and Non-Ferrous Sheet Metals, Bell Telephone Laboratories.

Used in general acceptance tests by Bell Telephone Laboratories and the Western Electric Co.

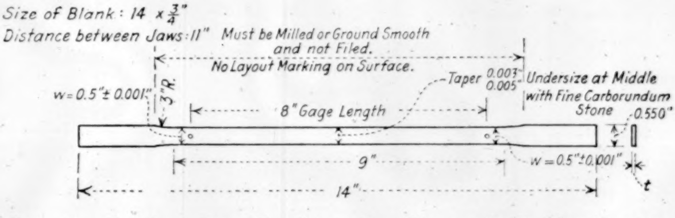
Size of Blank: 14 × 3/4"
Distance between Jaws: 11"
Must be Milled or Ground Smooth and not Filed.
No Layout Marking on Surface.
Taper 0.003" 0.005" Undersize at Middle with Fine Carborundum Stone
3" R.
w = 0.5" ± 0.001"
8" Gage Length
0.550"
9"
w = 0.5" ± 0.001"
14"
t

FIG. 9.—Tension Test Specimen for Ferrous and Non-Ferrous Sheet Metals, Bell Telephone Laboratories.

Used for stress-strain measurements. Elongation measured over 2 in. including fracture.

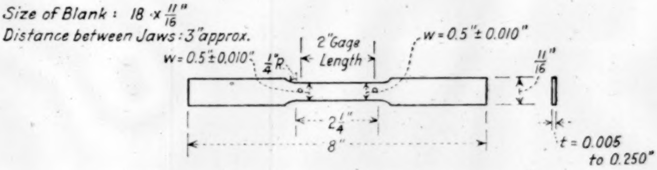
Size of Blank: 18 × 11/16"
Distance between Jaws: 3" approx.
2" Gage Length
w = 0.5" ± 0.010"
w = 0.5" ± 0.010"
1/4" R.
11/16"
2 1/4"
8"
t = 0.005 to 0.250"

FIG. 10.—Tension Test Specimen for Sheet Metals, Chase Companies, Inc.

Specimen blank usually sheared.

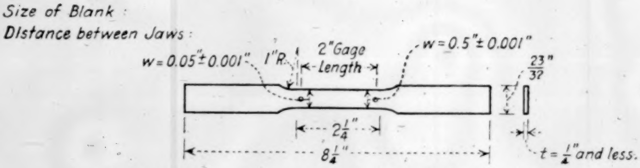
Size of Blank :
Distance between Jaws :
w = 0.05" ± 0.001"
1" R.
2" Gage Length
w = 0.5" ± 0.001"
23"/32
2 1/4"
8 1/4"
t = 1/4" and less.

FIG. 11.—Tension Test Specimen for Aluminum Alloy Sheet, Baush Machine and Tool Co.

Specimen blank given in Aeronautical Specifications No. 53-B.

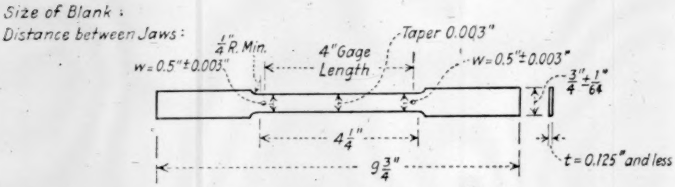
Size of Blank :
Distance between Jaws :
1/4" R. Min.
w = 0.5" ± 0.003"
4" Gage Length
Taper 0.003"
w = 0.5" ± 0.003"
3/4" ± 1/64"
4 1/4"
9 3/4"
t = 0.125" and less

FIG. 12.—Tension Test Specimen for Sheet Metal, and For All Sheet Except Aluminum, U. S. Army Air Service (Specification No. 10 021-1) and War Department, Watertown Arsenal.

This type of specimen blank is also standard with the Ordnance Department.

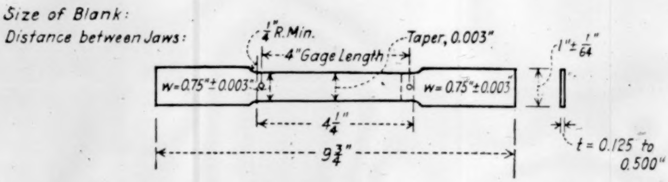
Size of Blank:
Distance between Jaws:
1/4" R. Min.
4" Gage Length
Taper, 0.003"
w = 0.75" ± 0.003"
w = 0.75" ± 0.003"
1" ± 1/64"
4 1/4"
9 3/4"
t = 0.125 to 0.500"

FIG. 13.—Tension Test Specimen for Sheet Metal, and For All Sheet Except Aluminum, U. S. Army Air Service (Specification No. 10 021-A) and War Department, Watertown Arsenal.

This type of specimen blank is also standard with the Ordnance Department.

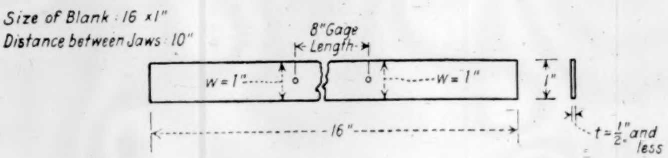
Size of Blank 16 × 1"
Distance between Jaws 10"
8" Gage Length
w = 1"
w = 1"
1"
16"
t = 1/2" and less

FIG. 14.—Tension Test Specimen for Sheet Metal, General Electric Co., Testing Laboratory.

Specimen blank sheared to ½ in. thick, milled for parallelism where necessary.

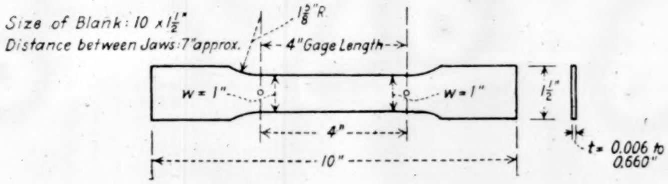
Size of Blank: 10 x 1½"
Distance between Jaws: 7" approx.
1⅜" R.
4" Gage Length
w = 1"
w = 1"
1½"
4"
10"
t = 0.006 to 0.660"

FIG. 15.—Tension Test Specimen for Hot-Rolled Steel Sheet, Cold-Rolled Steel Sheet, and Non-Ferrous Sheet, The Stanley Works.

Changed to this standard to agree with S.A.E. test specimen.

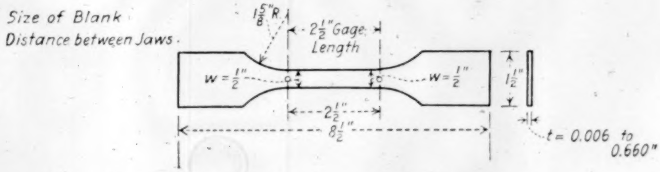
Size of Blank
Distance between Jaws
1⅝" R.
2½" Gage Length
w = ½"
w = ½"
1½"
2½"
8½"
t = 0.006 to 0.660"

FIG. 16.—Tension Test Specimen for Hot-Rolled Steel Sheet, Cold-Rolled Steel Sheet, and Non-Ferrous Sheet, The Stanley Works.

The Stanley Works formerly used this specimen and prefer it to type shown in Fig. 15.

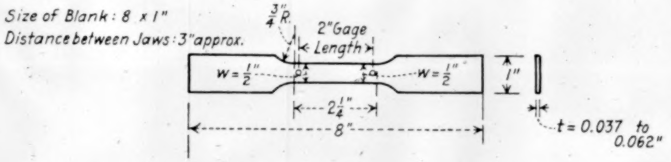
Size of Blank: 8 x 1"
Distance between Jaws: 3" approx.
¾" R.
2" Gage Length
w = ½"
w = ½"
1"
2¼"
8"
t = 0.037 to 0.062"

FIG. 17.—Tension Test Specimen for Sheet Steel, American Sheet and Tin Plate Co.

Specimen blank sheared.

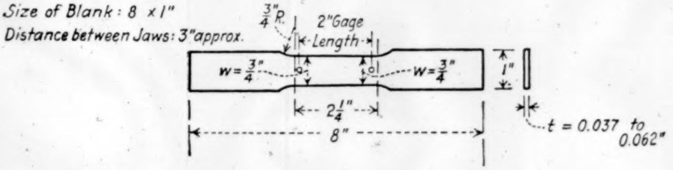
Size of Blank: 8 x 1"
Distance between Jaws: 3" approx.
¾" R.
2" Gage Length
w = ¾"
w = ¾"
1"
2¼"
8"
t = 0.037 to 0.062"

FIG. 18.—Tension Test Specimen for Sheet Steel, American Sheet and Tin Plate Co.

Specimen blank sheared.

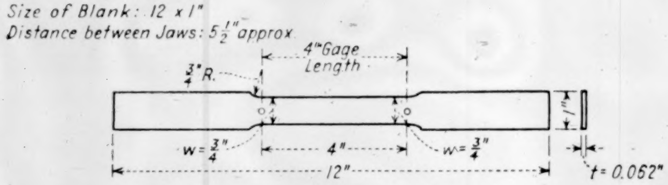
Size of Blank: 12 x 1"
Distance between Jaws: $5\frac{1}{2}$" approx.
4" Gage Length
$\frac{3}{4}$" R.
1"
w = $\frac{3}{4}$"
4"
w = $\frac{3}{4}$"
12"
t = 0.062"

FIG. 19.—Tension Test Specimen for Sheet Steel, American Sheet and Tin Plate Co.

Specimen blank sheared.

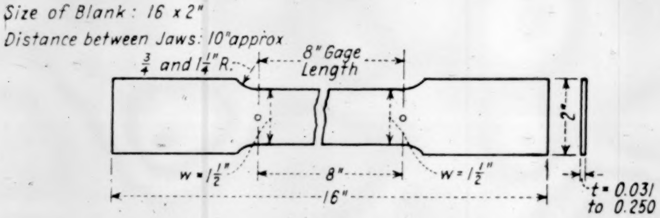
Size of Blank: 16 x 2"
Distance between Jaws: 10" approx.
$\frac{3}{4}$ and $1\frac{1}{4}$" R.
8" Gage Length
2"
w = $1\frac{1}{2}$"
8"
w = $1\frac{1}{2}$"
16"
t = 0.031 to 0.250

FIG. 20.—Tension Test Specimen for Sheet Steel, American Sheet and Tin Plate Co.

Specimen blank sheared.

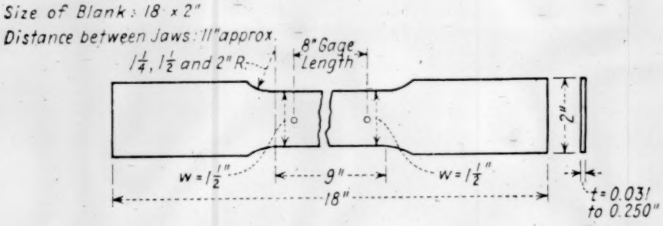
Size of Blank: 18 x 2"
Distance between Jaws: 11" approx.
$1\frac{1}{4}$, $1\frac{1}{2}$ and 2" R.
8" Gage Length
2"
w = $1\frac{1}{2}$"
9"
w = $1\frac{1}{2}$"
18"
t = 0.031 to 0.250"

FIG. 21.—Tension Test Specimen for Sheet Steel, American Sheet and Tin Plate Co.

Specimen blank sheared.

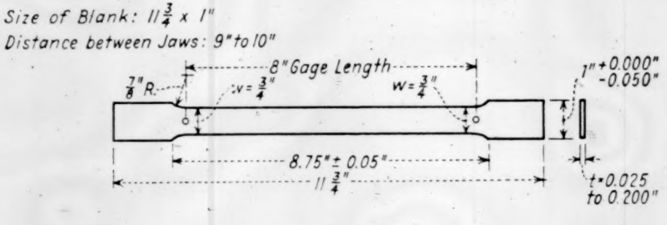
Size of Blank: $11\frac{3}{4}$ x 1"
Distance between Jaws: 9" to 10"
8" Gage Length
$\frac{7}{8}$" R.
w = $\frac{3}{4}$"
w = $\frac{3}{4}$"
1" +0.000" -0.050"
8.75" ± 0.05"
$11\frac{3}{4}$"
t = 0.025 to 0.200"

FIG. 22.—Tension Test Specimen for Sheet Steel, Edward G. Budd Co.

Specimen blank sheared.

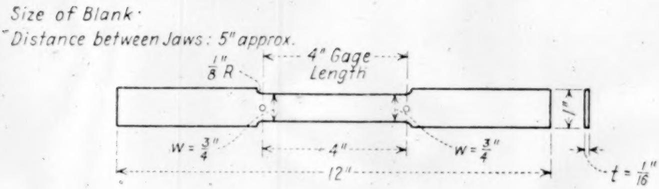
Size of Blank:
Distance between Jaws: 5" approx.
1/8" R
4" Gage Length
1"
w = 3/4"
4"
w = 3/4"
12"
t = 1/16"

FIG. 23.—Tension Test Specimen for Sheet Steel, Allis Chalmers Manufacturing Co.

Specimen tested for laminations.

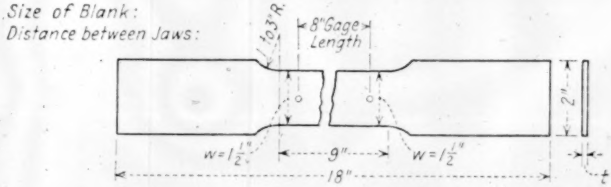
Size of Blank:
Distance between Jaws:
1 to 3" R
8" Gage Length
2"
w = 1 1/2"
9"
w = 1 1/2"
18"
t

FIG. 24.—Tension Test Specimen for Sheet Metal, Navy Department, Bureau of Construction and Repair, Engineering and Ordnance. General Specifications for Inspection of Material (July 1, 1919) and Federal Specifications Board Specification No. 339 (Used When an 8-in. Gage Length is Desired).

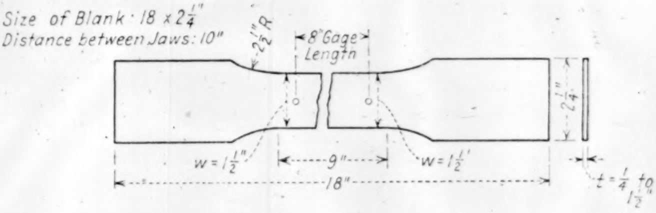
Size of Blank: 18 x 2 1/4"
Distance between Jaws: 10"
2 1/2" R
8" Gage Length
2 1/4"
w = 1 1/2"
9"
w = 1 1/2"
18"
t = 1/4 to 1 1/2"

FIG. 25.—Tension Test Specimen for Sheet Steel, Pennsylvania Railroad System, Test Department.

Specimen blank sheared.

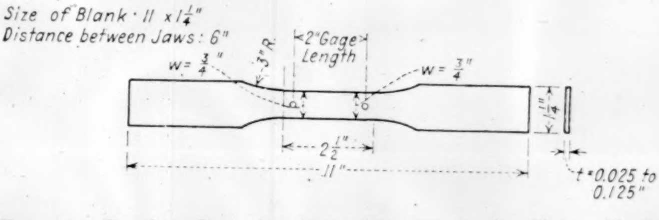
Size of Blank: 11 x 1 1/4"
Distance between Jaws: 6"
w = 3/4"
3" R
2" Gage Length
w = 3/4"
1 1/4"
2 1/2"
11"
t = 0.025 to 0.125"

FIG. 26.—Tension Test Specimen for Duralumin Sheet, U. S. Bureau of Standards.

Specimen blank sawed.

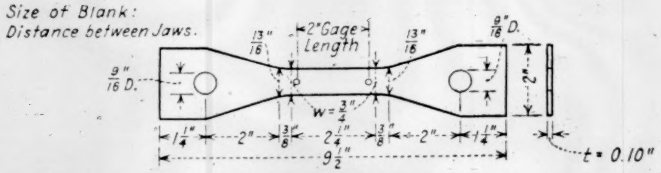
Size of Blank:
Distance between Jaws.
13/16"
2" Gage Length
13/16"
9/16" D.
9/16" D.
2"
w = 3/4"
1 1/4"
2"
3/8"
2 1/4"
3/8"
2"
1 1/4"
9 1/2"
t = 0.10"

FIG. 27.—Tension Test Specimen for Sheet Metal, International Nickel Co.

Pin joint used to hold specimen in testing.

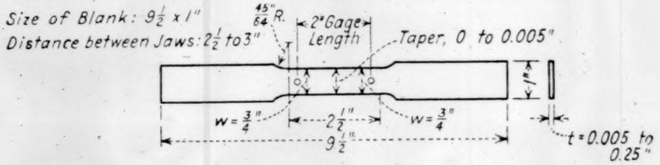
Size of Blank: 9 1/2 x 1"
Distance between Jaws: 2 1/2 to 3"
45/64" R.
2" Gage Length
Taper, 0 to 0.005"
1"
w = 3/4"
2 1/2"
w = 3/4"
9 1/2"
t = 0.005 to 0.25"

FIG. 28.—Tension Test Specimen for Sheet Metal, Westinghouse Electric and Manufacturing Co.

Specimen blank sheared for thin material; sawed for thick material.

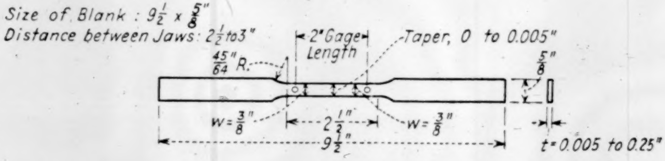
Size of Blank : 9 1/2 x 5/8"
Distance between Jaws: 2 1/2 to 3"
45/64" R.
2" Gage Length
Taper, 0 to 0.005"
5/8"
w = 3/8"
2 1/2"
w = 3/8"
9 1/2"
t = 0.005 to 0.25"

FIG. 29.—Tension Test Specimen for Sheet Metal, Westinghouse Electric and Manufacturing Co.

Specimen blank sheared for thin material; sawed for thick material.

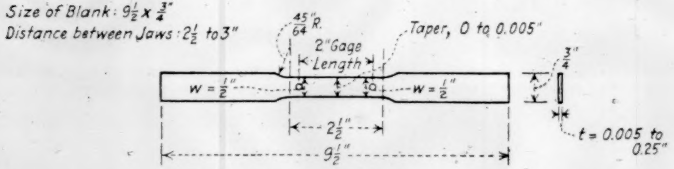
Size of Blank: 9 1/2 x 3/4"
Distance between Jaws: 2 1/2 to 3"
45/64" R.
2" Gage Length
Taper, 0 to 0.005"
w = 1/2"
w = 1/2"
3/4"
2 1/2"
9 1/2"
t = 0.005 to 0.25"

FIG. 30.—Tension Test Specimen for Sheet Metal, Westinghouse Electric and Manufacturing Co.

Specimen blank sheared for thin materials; sawed for thick material.

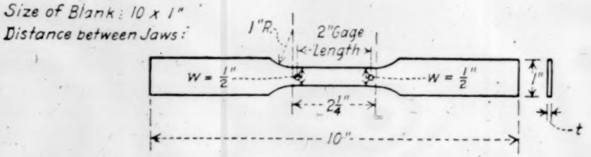
Size of Blank: 10 x 1"
Distance between Jaws:
1" R.
2" Gage Length
w = 1/2"
w = 1/2"
1"
2 1/4"
10"
t

FIG. 31.—Tension Test Specimen for Sheet Metal, New Jersey Zinc Co.

Standard pulling speed 0.286 in. per min.

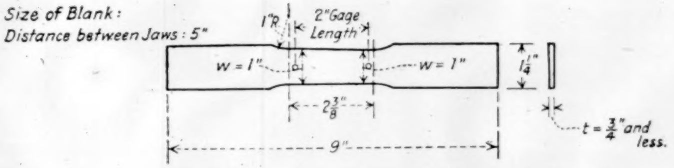
Size of Blank:
Distance between Jaws: 5"
1"R.
2" Gage Length
w = 1"
w = 1"
$1\frac{1}{4}$"
$2\frac{3}{8}$"
9"
t = $\frac{3}{4}$" and less.

FIG. 32.—Tension Test Specimen for Ferrous and Non-Ferrous Metals, Naval Gun Factory, Washington, D. C.

Used where a 2-in. gage length is specified as Specification 46B14C. When an 8-in. gage length is required use specimen shown in Fig. 24.

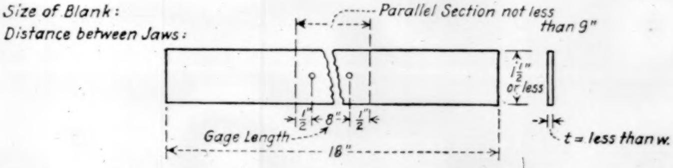
Size of Blank:
Distance between Jaws:
Parallel Section not less than 9"
$1\frac{1}{2}$" or less
$\frac{1}{2}$"
8"
$\frac{1}{2}$"
Gage Length
18"
t = less than w.

FIG. 33.—Tension Test Specimen for Sheet Metal, Federal Specifications Board Specification No. 339. (Used only when specimen shown in Figs. 24 or 35 cannot be obtained) and Navy Department, General Specifications for Inspection of Material (used only when specimen shown in Fig. 24 cannot be obtained).

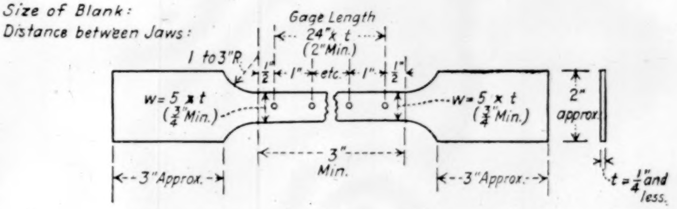
Size of Blank:
Distance between Jaws:
Gage Length
24" x t
(2" Min.)
1 to 3" R.
$\frac{1}{2}$"
1"
etc.
1"
$\frac{1}{2}$"
w = 5 x t
($\frac{3}{4}$" Min.)
w = 5 x t
($\frac{3}{4}$" Min.)
2" approx.
3" Min.
3" Approx.
3" Approx.
t = $\frac{1}{4}$" and less.

FIG. 34.—Tension Test Specimen for Ferrous Sheet, Standard of Society of Automotive Engineers.

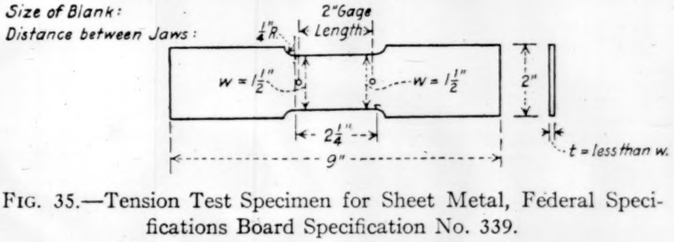
Size of Blank:
Distance between Jaws:
$\frac{1}{4}$"R.
2" Gage Length
w = $1\frac{1}{2}$"
w = $1\frac{1}{2}$"
2"
$2\frac{1}{4}$"
9"
t = less than w.

FIG. 35.—Tension Test Specimen for Sheet Metal, Federal Specifications Board Specification No. 339.

Used when a 2-in. gage length is specified. Where an 8-in. gage length is specified use specimen shown in Fig. 24.

II. SURVEY OF TEST SPECIMENS IN USE

An inquiry, outlining the proposed work of the section, was addressed to about forty leading organizations, including government departments, industrial laboratories, standardization boards, etc., requesting information on their present standard forms of tensile specimens for thin sheet metals. The response to this inquiry was very informative. At least 34 different types of specimen were found to be in use for thin sheet metals falling within the thickness range of the present investigation. These are shown in Figs. 2 to 35, which it is believed represent a fairly complete cross-section of present practice in this country. Analysis of these data shows the following:

SUMMARY OF SURVEY OF TENSION TEST SPECIMENS IN USE FOR TESTING SHEET METALS

Classified According to Gage Length and Width

GAGE WIDTH, IN.	2-IN. GAGE LENGTH	4-IN. GAGE LENGTH	8-IN. GAGE LENGTH
$\frac{3}{16}$	1	..	..
$\frac{3}{8}$	1	...	..
$\frac{1}{2}$	10	3	1
$\frac{3}{4}$	4	3	1
1	1	1	1
$1\frac{1}{2}$	1	..	5

NOTE 1.—One specimen varies from $\frac{3}{4}$ to $1\frac{1}{4}$ in. in width, and from 2 to 6 in. in gage length.

NOTE 2.—The specimens having a $1\frac{1}{2}$-in. gage width are based on the heavy steel plate tension specimen appearing in certain A.S.T.M. Standards.

It is significant that of the 34 different specimens represented in the survey, 10 are very close to the form developed in the analytical study outlined in Part I of this report. The remainder show considerable diversity in size and form. Five of the latter are intended primarily for use with material greater than $\frac{1}{4}$ in. in thickness and are obviously unsuitable for the testing of thin sheet metals of the thicknesses considered by this section.

III. EXPERIMENTAL STUDIES

An extensive investigation of the "Effect of Size and Shape of Test Specimen on the Tensile Properties of Sheet Metals" (including aluminum and aluminum alloys) has been made by Mr. Templin, a member of this section. The results of this work, together with published results of the work of H. A. Anderson and N. S. Otey, previously referred to, have been utilized in the analytical discussion in Part I of this report. Further investigations along similar lines, for steel, copper, zinc, and other materials, are being undertaken by members of the section and others. It is anticipated that the results of some of those investigations will be contributed as discussion of Mr. Templin's paper, which is to be presented at the June meeting of the Society.

IV. CONCLUSION

Notwithstanding a considerable demand for a standard tension test specimen for thin sheet metals, the section believes that further consideration and discussion of this subject should take place before an attempt is made to draft a tentative standard. The present report is submitted as a progress report only, as a basis for such further development and discussion.

Respectfully submitted on behalf of the Section on Testing Thin Sheet Metals,

H. C. KNERR,
Chairman.

H. A. ANDERSON,
Secretary.

[For a discussion of this report, see page 561.—ED.]

APPENDIX III

RÉSUMÉ OF THE FACILITIES AND METHODS FOR MAKING IMPACT TESTS, AND THEIR INTERPRETATION

This is a résumé of the "Symposium on Impact Testing of Material," *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part II, p. 5 (1922) and of the subsequent papers published in the Proceedings of the Society since 1922. It also reflects the discussions and the work done at different times by the Sub-Committee on Impact Testing of Committee E-1 on Methods of Testing.

Testing Machines

The Symposium mentions the different types of testing machines, but does not definitely bring out their advantages and the disadvantages. The types and their characteristics are:

Drop Weight Machines.—Frémont, Olsen, Hatt-Turner.

This type of machine, which has a vertically free falling hammer for the active element, seems to be preferred where fundamental research is the object, and where large forces are to be developed. The weight of the hammer in the different machines varies from 22 lb. to 500 lb. Usually these machines are fitted with a device for drawing, more or less automatically, the autographic space-time curve of the falling hammer, and the deflection curve of the specimen. Tension, compression, and the cross-bending or beam tests may be made on this type of machine.

Pendulum Impact Machines.—Charpy, Izod.

This type of machine is the most used of any, results of tests are indicated quickly, by a pointer, in energy units; that is, the energy absorbed by the specimen in breaking, or at its final deformation.

The Charpy machine is the best known and most widely used. The test specimen is a simple beam notched at the center; it is struck horizontally at the center between the supports by the swinging pendulum or hammer. The specimen may be bent, if failure does not occur, through a total angle of about 160 deg. Because of definite dimensions and being machine finished all over, it may be more definitely calibrated and checked by computations. It may be fitted for making impact tension tests.

The Izod machine is designed for the testing of a notched cantilever specimen. The specimen may be bent, if failure does not occur, through a total angle of 70 deg. In some cases it has been fitted for tension impact tests.

Flywheel Machines.—Guillery.

In this type of machine the striking edge is attached to a flywheel. The results are in terms of energy, and are indicated by the relative speeds before and after striking.

Miscellaneous.—There is mentioned in the Symposium a "Machine for Resilience Measurement Under Slow Application of Load" as the Humfrey machine for resilience measurement as notched bars subject to slow bending. Repeated impact machines are mentioned, in which the specimen is subjected to repeated impact of either constant value or of gradually increasing value, as the Stanton and the Matsumura machines.

Replies to the questionnaire relative to the testing machine, indicate:

1. That the Charpy and the Izod machines are by far the most generally used, with the Charpy having a preference over the Izod.
2. That the results are not sufficiently accurate and discriminating to indicate any but rather large differences in materials.
3. The results are in terms not applicable for use in design.
4. The results are not comparable between the different types of machines.

TEST SPECIMENS

The form of the test specimen is usually mentioned only in connection with the pendulum type of testing machines. Several forms have been used whose greatest variant is the size and shape of the notch. The one most used and most often suggested, whether for the simple beam or the cantilever type, is a specimen 10 mm. square, with a 45-deg. V-notch, 2 mm. deep having a bottom radius of 0.25 mm

MEASUREMENT OF IMPACT

Impact is thought of (1) in terms of energy (foot-pounds) or (2) in terms of force (pounds). The energy conception is the one most often used since it is the most easily measured, results being expressed as the energy absorbed by the test specimen.

Practically all investigators and students of impact seem to realize that the energy indication of a test is of little significance, the results cannot be used in design work, and they may be used only as a comparison of certain characteristics of similar materials.

Several attempts more or less successful have been made to obtain the actual pressure or force developed by impact. The fundamental method is by the aid of a space-time autographic curve traced by the striking hammer, giving the actual velocities at any instant. The maximum deceleration is obtained by taking the second differential of this curve. Then the product of mass and deceleration gives the actual force or pressure developed. The technics of this method are very difficult and the computations rather tedious. To obtain accurate results demands a rather high degree of expertness.

Another method is by the use of an accelerometer which, when attached to the striking hammer, will indicate directly the maximum deceleration.[1]

Methods of directly measuring impact pressure by either elastic or non-elastic deformations have been tried. By the elastic method, the attempt is made to measure the force by the deflection of springs, or of calibrated tension bars, or the indentation made by a steel ball or other spherical surface. The non-elastic method makes use of lead or of copper cylinders. In either case, the comparison is with that static force which will cause the same deflection or deformation. This method is not entirely accepted; there is always the suspicion that equal static and dynamic forces produce different deformations, and particularly so if the velocity of application of the impact force is very high.

RESULTS AND SIGNIFICANCE OF THE IMPACT TEST

A rather wide divergence of opinion exists as to the importance and the interpretation of the impact test. Authorities of equal standing often have entirely opposite views. Tests sometimes tend to support only partially any particular interpretation, and it is often difficult to appreciate and to explain the variations of any series of tests.

In a great majority of the work in impact testing, the object has been to get a certain result for one specific purpose, and then always on the assumption that the impact indications were definite in showing some certain property of the material. The effort has been rather feeble along the lines of fundamental research for the purpose of establishing or discovering the definite relations between impact indications and the characteristics and properties of materials.

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[1] E. B. Smith, "Accelerometer for Measuring Impact," *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part II, p. 626 (1923).

The testing of wood by an impact test is probably more uniformly done and better controlled than the impact testing of any other material. The Hatt-Turner machine is used for standard tests in the United States, Canada, and Great Britain. The test has not been standardized by any committee action of the A.S.T.M. or any other technical society in the United States.

The following quotations and opinions taken at random from the "Symposium on Impact Testing" (1922) and elsewhere from the Proceedings of the Society, show the general uncertainty and discrepancy in the art of impact testing. The figures following the page numbers indicate the position of the quotation on that page in quarters; that is, "3" indicates the third quarter.

". . . Static bending tests were also made on specimens cut from the same boards as the impact specimens. As was to be expected, comparison showed the values under the impact test to be considerably higher than were obtained in the static test, the maximum load being about 75 per cent higher, deflection at which maximum load occurred 25 per cent higher, and work consumed up to maximum load 100 per cent higher. The force-deflection curves had the same general form as load-deflection graphs derived from static bending, although not exactly similar since the ordinates of the force-deflection graph exceed the ordinates of the load-deflection graph by a greater percentage than do the abscissas. Thus there is some indication that the energy absorbed by the stick in the impact test does not indicate any different property than does the energy absorbed in a static test. However, generalization along this line is not justified by tests on a single species and particularly from a single board, as were the specimens compared in these tests. Comparison was also made of the energy consumed as determined from the difference of kinetic heads before and after breaking the specimen plus the work done by gravity during the deflection with the area under the force-deflection curve. These comparisons for six beams showed that the maximum value of the energy unaccounted for by the area under the force-deflection curve was about 5 per cent."—Wilson, p. 57–1.

"In the woods of highest shock resistance a large proportion of the shock resistance is developed after passing the elastic limit. The contrary is true of sticks of low toughness; consequently the latter have an advantage under increment-drop tests since the number of drops applied after the elastic limit is passed and actual damage to the stick begins to occur is much less than in the woods of highest shock resistance. For this reason it is perhaps a fact that when the drop used to cause complete failure in the increment test is used as the basis of comparison the true magnitude of the difference between tough and brittle specimens is not shown. This, however, does not make the test any less valuable as a means of classifying species or specimens in their proper order with respect to shock-resisting ability.

"Values in fiber stress at elastic limit as obtained from the increment-drop test show, as do numerous other tests, that the strength values developed in wood increase very materially with increase in the rate at which strain is applied. For air-dry wood, fiber stresses at elastic limit as obtained from the impact test averages nearly twice as great as the same quantity from static bending tests and about 35 per cent higher than modulus of rupture. Elastic resilience averages nearly three times as great as in static bending. These comparisons are based on the tests of 126 species previously mentioned."—Wilson, p. 67-2.

A difference of opinion exists as to the relative effect of the total energy of a number of blows of increasing magnitude and that of a single blow, failure being produced in each case, p. 41-4.

"Knowledge in regard to the influence of the velocity of the hammer on resilience has been in a chaotic condition."—McAdam, p. 42-2.

". . . Fremont and the laboratory of the Paris-Lyons . . . Mediterance Railway Co. . . . agree in the conclusion that resilience values are affected by velocity of hammer at impact."—McAdam, p. 43-2.

Cornu-Thenard in an elaborate series of tests . . . height of drop of hammer from 0.71 meter to 6.45 meters . . . conclude, the resilience values are uninfluenced by type of machines used, the weight of hammer and anvil, and the velocity of hammer at impact, p. 44-1.

"Hadfield states that since the object of shock testing is to detect variations of resistance between rapidly and slowly applied stresses, the velocity of impact should be considered and advocates the determination of a curve to show the reduced resistance to shock, as velocity increases, and also states that velocity should be great enough to determine brittleness in all specimens."—C. L. 4833. Lynch, p. 101-2.

"Ratio of impact resilience to static resilience . . . available data is meager. Blount, Kirkaldy and Sankey, show a ratio of 1.31 to 1.75, the average being 1.58. U. S. Naval Experiment Station tests show ratio of 1.03 to 1.72, the average being 1.36. . . . The available data, therefore, would indicate that impact resilience is in general greater than static resilience."—McAdam, p. 45.

"In the case of testing rock for road use, the height of final fall in centimeters to cause failure is taken as the toughness. This toughness value increases with the hardness of the stone."—Smith, p. 75-1.

"Several laboratories point out that the tests at present made are not especially adaptable to ductile materials . . . results are in units inapplicable to the problems at issue. In discussing the comparability of results obtained from the different types of impact machines, the opinion is rather general that these results cannot be very satisfactorily compared. . . . May not be in absolute sense, may be in relative sense." Discussion of Questionnaire. Warwick, p. 81-4.

The questionnaire brought out some interesting replies to the question, "In what particular line do you consider impact tests of the most use?" (Answers) . . . "to determine degree of toughness of metal by heat treating;" . . . "check on specified heat treatment;" . . . "substitute for static test to disclose impairment of ductility;" . . . "in the study of causes of failure;" . . . "in the study of materials subject to shock under serious conditions."—Warwick, p. 81-4.

"That the properties required of parts subject to severe impact stresses are such as to call for the use of material in a more or less hard state rather than in the condition in which it will consume a larger number of work units in an impact test, is not a contradiction of the value of the impact test, but only of an erroneous application of the results in the assumption that the number of foot-pounds consumed is a direct index of the ability of the material to withstand impact service."—Margerum, p. 105–1.

"The conclusions are diversified, but taking into account the more recent work . . . it is believed that the proper conclusion . . . is that the relationship [between static and dynamic results] will vary with the nature of the material undergoing comparison."—Langenberg-Richardson, p. 128–4.

"Regardless of the type of impact machine employed or form of specimen used, the essential result furnished is the amount of energy absorbed by the specimen. . . . In comparing static and dynamic tests, therefore, the same essential data should be recorded in both cases . . . it is, therefore, impossible to draw any definite relationship between the values usually recorded in the tension test and the data obtained from the impact test." Summary of Statement by Langenberg-Richardson, p. 129–4.

. . . "it can be stated definitely that the elastic limit and tensile strength [of steel, annealed and heat-treated] plotted as a function of the work done on the Charpy specimen gave not the remotest idea of any relationship."—Langenberg-Richardson, p. 130–4.

In comparing the tensile strength and shock tests of heat-treated cast and extruded aluminum bronzes, R. R. Moore says: "Elongation evidently is no measure of shock resistance of grooved or notched bars."—*Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 553–3 (1924).

"It is evidently quite dangerous to attempt to judge the relative value of metals by a comparison of the number of blows they will withstand to fracture, at a fixed energy of blow, as it is doubtful what property is being measured."—R. R. Moore, *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 572–4 (1924).

"The repeated impact test results are influenced by both the materials' resistance to shock and its resistance to fatigue."—R. R. Moore, *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 573–4 (1924).

QUESTIONS RAISED AND NOT ANSWERED

1. Does the ratio of impact resilience to static resilience vary with the shock resisting quality of the material?
2. How may the foot-pound unit, as obtained from an impact test, be used in engineering work?
3. If the results of an impact test were given in terms of actual pressure or force (in pounds), could they be more directly used for comparison or in design work?
4. Can impact tests at present be used to compare materials of different kinds?
5. Is there a definite relation between the results of an impact test (in foot-pounds) and the results of any form of a static test?
6. May impact tests serve to control the production of any material to specification?
7. Will the repeated impact test carried to failure give the same results as one blow causing failure?

8. Are there any of the impact machines as now manufactured superior to all others as to accuracy and general arrangement for development and research work?

9. What is an impact test, what is the speed of deformation which distinguishes it from a high-speed static test?

10. Should a "suddenly applied load," without actual collision or impact, be classed as an impact?

11. What properties of materials does the impact test definitely determine? Toughness? Hardness? Brittleness? Ductility? Endurance Limit? Resistance to shock? Any relation to the static strength properties?

12. Are the properties of a material the same, or comparable, under impact as they are under static conditions.

APPENDIX IV

PROPOSED METHODS OF IMPACT TESTING OF METALLIC MATERIALS

1. These methods deal with the calibration and use of the impact testing machine and with the form and dimensions, the preparation, and the testing of the impact test specimen of metallic materials. Such matters as the taking of the samples from which to prepare test specimens, and their heat treatment are not covered here.

I. DEFINITIONS

2. (*a*) *Impact.*—The act and the result of the colliding or the striking together of two bodies. It may be expressed in terms of force or of energy.

(*b*) *Impact Force.*—The force or pressure developed by impact, and measured in simple force units (pounds or kilograms).

(*c*) *Impact Energy.*—A careful distinction should be made in the use of this term. (1) Striking energy is the energy possessed by the moving body by virtue of its mass and velocity, and it may be entirely independent of any actual impact. (2) Absorbed impact energy is the energy actually absorbed by the impact. Impact energy is measured in the compound unit of foot-pounds, or kilogram-meters.

(*d*) *Impact Stress.*—The stress induced in a material as a result of an impact force, measured in pounds per square inch, or kilograms per square centimeter.

II. THE IMPACT TESTING MACHINE

3. The pendulum type, small Charpy design, of impact testing machine is recommended as the standard machine for making standard routine tests, for making research studies relative to the properties of metallic materials, and for the interpretation of test results. It should be sensitive to 0.1 ft-lb.

4. This type and design of testing machine is chosen for the following reasons: The pendulum type may be used more readily for measuring the energy absorbed by a test specimen; the indications are made direct on a scale, and the calibration of the machine is easily computed and checked.

5. The Charpy design is chosen because of its greater range of striking velocity (nearly 18 ft. per second) and greater striking energy (217 ft-lb.). It may be used for testing small specimens in tension. Its normal test specimen is a simple beam which may be bent during test through a total angle of about 160 deg. if fracture does not occur. The blow is always directed tangentially to the swing of the pendulum, and in no case is a radial or an angular component produced either on the pendulum or on the test specimen. It is probably more convenient for attaching to the pendulum some form of accelerometer or other force measuring device. It is more widely used than any other impact testing machine.

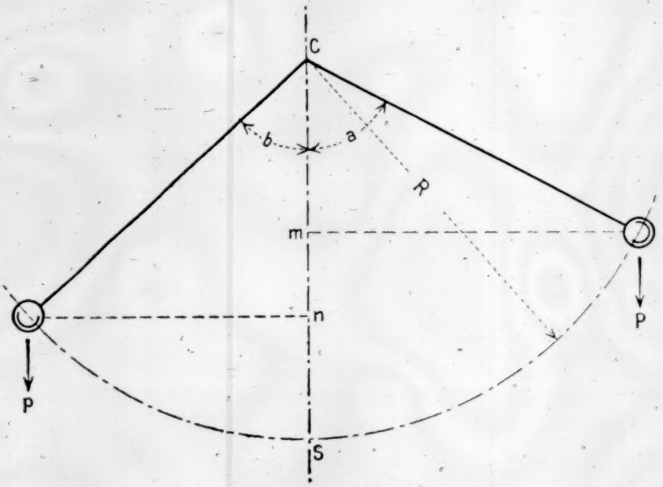

FIG. 1.

6. *Calibration by Calculation.*—The energy absorbed in breaking a test specimen in a testing machine of the pendulum type is equal to the difference of the energy in the pendulum before and after impact.

7. Referring to Fig. 1: Let P be the weight of pendulum and rod; R be the radius of center of percussion of the pendulum and rod; a the initial angle of pendulum movement; b the final angle after striking specimen, at s; e_1 and e_2 are, respectively, the initial and final energy in the pendulum; and the energy absorbed by the test specimen.

$$\begin{aligned} E &= e_1 - e_2;\ \text{then} \\ e_1 &= Pms = PR\,(1-\cos a) \\ e_2 &= Pns = PR\,(1-\cos b) \\ \therefore \mathrm{E} &= PR\,(\cos \mathrm{b} - \cos \mathrm{a}) \end{aligned}$$

8. Although the pendulum operates on a nearly frictionless bearing, there should be a correction applied to the above value for *E*, due to the energy lost in friction. This correction may be made by trial on the testing machine by noting the values of the angles *a* and *b* when dropping the pendulum and allowing it to swing through freely without striking a test specimen, all parts of the machine being operated exactly as during the test. Then under this condition, the energy lost by friction is E', computed same as *E* above, but this is the energy loss for a full swing. The net correction to be applied to each test is FE', where *F* is the ratio of actual swing (or total angle) to full swing without test.

III. TEST SPECIMENS

9. In recommending the following test specimens for use in impact tests, it is not intended to exclude entirely the use of such other test specimen as may be necessary for special materials, or for use in making research tests to determine the effect of form of test specimen, or to determine special properties of materials. It is, however, recommended that wherever feasible the specimens here recommended be used.

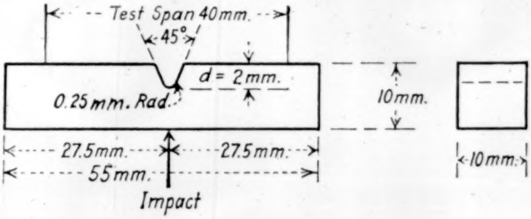

FIG. 2.—Test Specimen for Transverse Impact Tests.

10. The test specimen for the regular impact transverse test shown in Fig. 2 is recommended for use in all possible cases. Round, plate, and shape material should be reduced to this form and dimension. The form and dimensions of the notch are very important, and for hard materials may possibly be best made by grinding.

11. The test specimen for impact tension tests shown in Fig. 3 is recommended for use in all possible cases. This form without a notch is recommended as possibly the best one for use so that comparisons may also be made with the static tension test.

12. Test specimens should always be finished smooth and free from nicks, tool marks or appreciable polishing scratches.

13. The transverse impact test specimen should be accurately placed in the testing position by means of a gage, or jig.

IV. OPERATION OF TESTING MACHINE

14. Care must be taken to prevent giving the pendulum an impulse in starting. The swing of the pendulum must be from a free start at its initial position.

15. The initial position, and the friction corrections should be checked frequently.

16. The regular standard impact test is accomplished by one blow of the pendulum, and it shall be struck at the center point on the side opposite the notch.

17. The striking edge of the pendulum shall be of hard tempered steel, having an included angle of 45 deg. with the edge rounded to a radius of $\frac{1}{8}$ in.

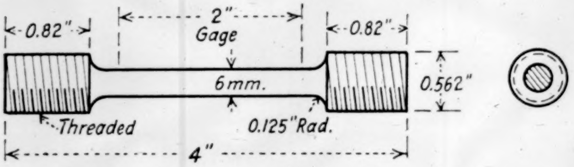

FIG. 3.—Test Specimen for Impact Tension Tests.

V. DETERMINATION OF AND REPORTING THE RESULTS OF TEST

18. *Force.*—The force required to rupture, or to produce maximum deformation, shall be reported in pounds (kilograms), total, for both the transverse and the tension impact test. The method or means used for determining the impact force should be described in detail. The value of the mass of the pendulum and when possible the deceleration should be given in the report.

19. *Energy.*—The energy absorbed in rupturing, or in producing the maximum deformation, is to be reported in foot-pounds (kilogram-meters) for both the transverse and the tension impact test.

20. *Velocity.*—The velocity of the hammer at the instant of striking should always be given, as this probably will have some influence on the amount of energy absorbed by some materials. The velocity may be computed by the formula,

$$V = 2\,gh$$

where h is the vertical height of fall of the pendulum.

21. *Temperature.*—For standard test results the test specimen should be tested at a temperature of 21° C. (70° F.). For specific results on materials to be used at high temperatures, care must be taken to maintain the specimen at the required temperature.

NOTE.—Present indications are that entirely different results will be obtained in an impact test, as in the tension test, on materials tested at different temperatures, and that some characteristics and properties may be relatively higher in numerical value and some lower.

APPENDIX V

ANALYSIS OF RETURNS ON QUESTIONNAIRE ON ACTIVITIES OF TESTING LABORATORIES ON IMPACT TESTING

Under date of October 27, 1925, a questionnaire was submitted by the Sub-Committee on Impact Testing to 62 laboratories to learn if these laboratories were at present conducting or were interested in research work in impact testing. It was felt that this information should be of interest to all those engaged in impact testing, since in this way it would make it possible for each individual laboratory to know which other laboratories are engaged in some particular problem. The following questions were asked:

1. Is your laboratory now actively engaged in research work in connection with the impact test?
2. What particular problem or phase of the impact test are you studying and what is it planned to accomplish?
3. The extensiveness of the investigation.
4. The type of testing machine used in the investigation.
5. The terms or units in which the results are given.

Thirty-nine replies were received. Of these, 9 laboratories indicated that no work on impact is being carried on at the present time. Six laboratories replied that no work is now being conducted but that the laboratory is interested in impact testing and is prepared to cooperate in any investigation that is carried out. Twenty-four laboratories, divided in the following analysis into those engaged in research work and those engaged in impact testing although not necessarily in research work, have replied in detail to the five questions and their replies are given in the accompanying Table I.

TABLE I.—ANALYSIS OF QUESTIONNAIRE ON IMPACT TESTING.

Laboratory	Question No. 1	Question No. 2	Question No. 3	Question No. 4	Question No. 5
LABORATORIES INTERESTED IN RESEARCH WORK ON IMPACT TESTING					
A	Work on drop testing of gray cast iron.	Drop test results compared with tensile, transverse, Brinell, Shore, Rockwell and other tests of various grades of cast iron.	Made daily for past three years.	Laboratory's own design with vertically falling tup.	Foot-pounds of energy to rupture.
B	Considering one phase of impact testing.	Relationship between static and dynamic test results.	Depends on future test results.	Charpy machine 300 kg-m. capacity.	Foot-pounds of energy absorbed.
C	Certain amount of investigative work.	Relation between impact and slow bend test.	Work to continue for some time.	Izod and Charpy impact and Humfrey slow bend machine.	Foot-pounds, 10 mm. or $\frac{3}{8}$-in. square test bar.
D	Impact test used in routine testing and research work.	Comparison of relative values of gas and electric welds to resist repeated impact. Determination of proper quenching temperature of steels.	Varies with purpose in view.	Charpy, Izod and Stanton.	Charpy and Izod, foot pound; Stanton, energy of blow and number of blows.
E	Some work being done on impact.	Absorption of force throughout section about notch; correlation of impact results with other physical data.		American made Charpy machine.	Foot-pounds necessary to break standard notched bar.
F	Problem now under way.	Comparison between static and impact energies of rupture in tension and transverse bending of steels.		Russell Pendulum; capacity 8000 in-lb. with special attachments.	Notched specimens inch-pounds; tensile specimens inch-pounds per cu. in.
G	Yes.	Impact values of various grades, sizes and treatments.	All general export stock.	Izod and Charpy.	Foot-pounds.
H	Preliminary work, tests on steel.	Study of stresses occurring during impact.		Izod single blow Krupp repeated blow. (Future use) Stanton.	Foot-pounds. Inch-pounds. Inch-pounds
LABORATORIES ENGAGED IN IMPACT TESTING (NOT NECESSARILY RESEARCH WORK)					
I	No active research work at present; some tests made.	Determination of suitability of impact test for use on aluminum and magnesium; and evaluation of impact strength of these metals. Tests on alloys of aluminum and commercially pure metal. Few on magnesium.	Tests made from time to time.	Olsen-McAdam, arranged to make impact and shear impact tests, either round or square specimens, cantilever type, with two hammers giving capacities of 25 and 50 ft-lb.	Foot-pounds.
J	Only drop tests with 1000-lb. tup on draft gears.				
K	Tests made on various steels.	Differentiate between sound and unsound material not indicated in static tension tests.		Izod	
L	Investigation just completed.[a]				

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[a] See paper by S. N. Petrenko, Technologic Paper No. 289, Bureau of Standards.

TABLE I.—ANALYSIS OF QUESTIONNAIRE ON IMPACT TESTING (*Continued*).

Laboratory	Question No. 1	Question No. 2	Question No. 3	Question No. 4	Question No. 5
M	Not now actively engaged in research.	None.	None.	Izod machine.	Foot-pounds of energy absorbed.
N	No investigation; occasional tests.			Charpy machine.	
O	No research work relative to impact testing alone.	Problems involving steel manufacture and analysis.		Guillery and Izod.	Kilogram meters (Guillery); foot-pounds (Izod).
P	No research; impact tests made in past.	Determination of properties of various steels.	(Greatly interested in any developments.)		
Q	No research.	Routine testing.		Izod and Charpy.	
R	No research.	Occasional impact tests.		Olsen and Charpy special light-weight hammer[a]	
S	Work expected to be done in future	Machine recently bought as addition to outfit.		Charpy (furnished by Prof. Sauveur, French design).	(Glad to cooperate.)
T	Investigation carried out few years ago.[b]				
U	No research work.	Considerable work done on impact testing.		Charpy.	(No funds for research Glad to cooperate, however.)
V	No research; data on heats of alloy steel.	Relation of one type of impact test to other physical properties.	Covers a period of five years.	Izod, Fremont, Stanton.	Kilogram-meters and foot-pounds.
W	No research work.	Standard tests on wood.		Hatt-Turner.	
X	No extended research work.	Tests made as class room exercises.		Olsen-Charpy.	

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[a] See paper by E. H. Dix, Am. Inst. Mining and Metallurgical Engrs.

[b] See paper by P. Heymans, Am. Soc. Steel Treating. (Question of having investigation financed on stress distribution in different types of test by means of photo-elastic method.)

DISCUSSION

Mr. Peirce.

MR. W. M. PEIRCE[1].—At about the time that our laboratory was asked for information concerning our method of making tension tests on thin rolled zinc, we became acquainted with the work being done by Mr. R. L. Templin on aluminum. Before replying to the request, Mr. Finkeldey and the writer had a series of tests made along lines suggested by Mr. Templin's work. That is, we studied the effect of varying the width of the ends of the tension specimen which we use (illustrated in Fig. 31 of the committee's report) and of varying the radius of the fillets.

The results of our tests are given in the accompanying table and indicate that within wide limits, variations in the radius of the fillets and the end width have no effect on the tensile properties in the case of rolled zinc between thicknesses of 0.010 and 0.025 in.

SUMMARY OF TESTS MADE IN CONNECTION WITH REQUEST FROM COMMITTEE E-1 FOR DATA ON SHEET ZINC TENSION TESTING.

Each figure represents average of 6 specimens.

		THICKNESS, 0.010 IN.		THICKNESS, 0.025 IN.	
WIDTH, IN.	RADIUS, IN.	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION, PER CENT	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION, PER CENT
⅝	½	18 700	43.6	19 100	49.6
¾	½	19 100	43.9	19 400	55.3
1	½	19 100	48.0	19 000	53.6
⅝	1½	19 500	48.9	19 200	53.2
¾	1½	19 500	44.8	19 000	56.2
1	1½	19 200	49.9	18 800	52.6
⅝	3	19 200	46.4	19 200	51.3
¾	3	19 400	45.5	19 100	53.8
1	3	18 900	47.5	18 700	51.8

Mr. Anderson.

MR. HARVEY A. ANDERSON.[2]—On behalf of the Section on Tests of Thin Sheet Metals certain information is presented here that became available too late for incorporation in its report. Most of the replies to the questionnaire which have been received subsequently

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[1] New Jersey Zinc Co., Palmerton, Pa.

[2] Bell Telephone Laboratories, Inc., New York City.

Mr. Anderson. have come through foreign standardizing bodies which have been questioned through the cooperation of the American Engineering Standards Committee. Information has been received from Belgium, Denmark, and Norway that those countries have no standard form of test specimen for thin sheet metals. Great Britain reports a test specimen for steel, copper and brass sheets for aircraft which has a reduced section $1\frac{1}{4}$ in. wide by 4 in. long. For aluminum sheet for aircraft they have a specimen $\frac{1}{2}$ in. wide for material thinner than 0.050 in. and up to $1\frac{1}{2}$ in. wide for thicker material. The parallel length is specified as not less than $2\frac{1}{2}$ in. and the radius at the shoulders as not less than $3\frac{1}{2}$ in.

Switzerland reports the use of a form of test specimen for thin sheet metals in which the gage length, the width, and the length of the reduced section is made proportional to the thickness of the material. The formula gives a gage length of approximately 2 in. for a thickness of 0.050 in. and of 8 in. for a thickness of 0.2 in. It is probable that Swiss laboratories find it undesirable to use specimens conforming with these proportions in all cases because the indicated value of twelve times the thickness for the width of specimen would result in a specimen about $2\frac{1}{2}$ in. wide for a thickness of 0.2 in. The Section on Tests of Thin Sheet Metals found that it was impracticable to recommend specimens based upon any such relationship of the other dimensions to the thickness.

REPORT OF COMMITTEE E-4
ON
METALLOGRAPHY

Committee E-4 has held its customary three meetings during the year: at the annual meeting at Atlantic City, June 24, 1925, the second at Cleveland, Ohio, September 16, 1925, in conjunction with the meeting of American Society for Steel Treating, and the third at New York City, February 15, during the winter meeting of the American Institute of Mining and Metallurgical Engineers. The two mid-year meetings were arranged at the places specified to enable members of the three societies mentioned to attend both events at a minimum of expense.

Sub-Committee I on Selection and Preparation of Samples, William Campbell, chairman, has submitted an interesting and instructive report which was compiled by G. F. Comstock. As part of this report, E. C. Groesbeck of the U. S. Bureau of Standards has presented a paper on "Etching Reagents for Carbides, Etc., in Alloy Steels." The report of Sub-committee I and Groesbeck's paper are appended hereto. The report of the sub-committee contains proposed revisions of the Standard Methods of Metallographic Testing of Non-Ferrous Metals (E 5 – 24) which the committee recommends be accepted for publication as tentative.

Sub-Committee II on Nomenclature and Definitions, A. Phillips, chairman, at the request of the committee has presented the following definiton of "Metallography," which was approved and the recommendation made that the definition be presented to the Society for acceptance for publication as tentative:

> "Metallography is the study of the constitution and structure of metals and alloys and their relation to the physical and chemical properties.

The sub-committee at the present time is working in conjunction with Sub-Committee VI on several definitions related to X-ray analysis, radiography, etc.

Sub-Committee V on Micro-Hardness, H. S. Rawdon, chairman, has submitted an unusual report on a subject about which little is known, and the summary and bibliography will prove of great value to those interested in this phase of metallography. The complete report is appended hereto.

Sub-Committee VI on X-ray Metallography, Zay Jeffries, chairman, presents a proposed Recommended Practice for Radiographic

Testing of Metal Castings, prepared by H. H. Lester of the Watertown Arsenal. All persons interested in X-ray Radiography will appreciate this piece of work. It is recommended that this recommended practice be accepted for publication as a Tentative Standard. In connection with this sub-committee's report is presented, as an appendix, a very complete Glossary of terms used in X-ray Metallography. It was prepared by L. W. McKeehan of the Bell Telephone Laboratories and is the most exhaustive of anything yet published along this branch of metallography.

As was mentioned in the report of Committee E-4 last year, instructions on the care of the eyes when using a metallographic microscope have been prepared by W. L. Patterson of the Bausch & Lomb Optical Co.[1] These are recommended for publication as tentative to be added, when adopted, as an appendix to the present Standard Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2 – 24).[2]

A general recommendation was made and approved by the committee at its Cleveland meeting that the A.S.T.M. should print photomicrographs on a better grade of paper and use a finer screen. Such a procedure would enhance greatly the value of the reports and papers on Metallography.

This report has been submitted to letter ballot of the committee, which consists of 48 members, of whom 41 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. C. BOYNTON,
Chairman.

G. F. COMSTOCK.
Secretary.

EDITORIAL NOTE

The proposed Recommended Practice for Radiographic Testing of Metal Castings, recommended by the committee, were accepted for publication as tentative and appear on page 1093. The proposed Recommended Practice for The Care of the Eyes when Using a Metallographic Microscope was accepted for publication as tentative to be added, when adopted, to the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys. It appears on page 1096.

The proposed revisions of the Standard Methods of Metallographic Testing of Non-Ferrous Metals were accepted for publication as tentative and appear on page 1142. The proposed Tentative Definition of the Term Metallography was accepted for publication as tentative as a revision of the Standard Definitions of Terms Relating to Metallography, and appears on page 1092.

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[1] See p. 1096.—ED.

[2] 1924 Book of A.S.T.M. Standards.

REPORT OF SUB-COMMITTEE I ON SELECTION AND PREPARATION OF SAMPLES

The following new developments in metallographic methods have come to the attention of the sub-committee during the past year:

> Molten sulfur is a convenient medium for mounting small specimens, as it has good polishing properties and is neutral toward etching reagents. It has been used with success by Mr. Coleman and Mr. Epstein of the U. S. Bureau of Standards, who recommended it to the committee.
>
> According to the Union Carbide and Carbon Research Laboratories, a good etching reagent for chromium alloys is made by mixing 1 part HNO_3 and 2 parts HCl, and diluting this mixture with an equal quantity of glycerin; also a good etching reagent for copper alloys is 15 per cent c.p. chromic acid in water, with 1 drop of HCl added per 50 c.c.

The sub-committee also submits as part of its report a paper by Mr. Groesbeck of the U. S. Bureau of Standards on "Etching Reagents for Carbides, Etc., in Alloy Steels." This paper is appended hereto.

The following revisions of the Standard Methods of Metallographic Testing of Non-Ferrous Metals and Alloys (E 5 - 24)[1] are recommended for publication as tentative as applying to Aluminum Alloys. This work is due to Mr. E. H. Dix, Jr. and Mr. W. D. Keith of the Aluminum Company of America:

Referring to the 1924 Book of Standards, the first sentence on page 1168 should be replaced by the following paragraph:

> "For aluminum and its alloys, a solution of HF-HCl (Solution 2) is recommended. Ten-per-cent aqueous solution of NaOH and 10-per-cent HF also give good results. In copper-bearing alloys, the latter solution should be followed by a cleaning in cold concentrated HNO_3."

Under "Method of Polishing" on page 1168, the following paragraph should be added, covering the polishing of aluminum and its alloys:

> "In the preparation of specimens of aluminum and its alloys, the same precautions must be followed which are recommended for other soft metals. It is further recommended that following the cut on the file, two coarse emery papers, No. 2 and No. 1, be used, preceding the use of the finer metallographic polishing papers. The papers should be prepared by applying a solution of paraffin in kerosine and working well into the surface. The polishing must be done by hand. The papers may be used either as so prepared or moistened with additional solution. It is not always necessary to use this solution on the coarse papers, No. 2 and No. 1. The hand polishing may be stopped at either No. 000 or No. 0000 paper and the polishing continued on a wheel revolving at

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[1] 1924 Book of A.S.T.M. Standards.

approximately 200 r.p.m. For the first cut on the wheel, a coarse grade of broadcloth is used with a grade of abrasive similar to 65-*F* alundum. The next cut is made using a softer broadcloth and 'heavy magnesium oxide,' applied as follows: The pad is moistened with distilled water and approximately one teaspoonful of powder applied evenly to the surface and thoroughly rubbed in, all hard and coarse particles being brushed off with the hand. After the scratches left by the 65-*F* material have been removed the pad is washed clean and a smaller quantity of powder worked in as before. This time the cut is made at right angles to the first treatment. This procedure may be repeated several times until the specimen shows a brilliant, reflecting surface and under the microscope the aluminum solid solution matrix appears clear white and the constituents stand out in even colors, free from tarnish. Only distilled water should be used during the polishing with the magnesia powder, otherwise there is danger of forming particles of carbonate, which are harsh and scratch the specimen. It is good practice to frequently raise the specimen from the pad and revolve it 180 deg. before replacing. The pressure and quantity of water to be used can only be determined after considerable practice and varies with the nature of the alloy."

At the bottom of page 1169, it is recommended that the following paragraphs and table be inserted:

"Etching reagents for the identification of constituents in aluminum and its alloys are generally unsatisfactory. Reagents intended to differentially color specific constituents are uncertain and their action varies in different alloys and especially under different conditions of polishing. For this reason it is recommended that the specimens be carefully polished and examined in the unetched condition. If a light filter is used to give a source of light approximating daylight, the constituents will appear as described below:

UNETCHED CHARACTERISTICS.

Constituent	Color	Usual Shapes	Characteristics
Si	Slate.	Irregular plates.	Easily recognized.
$FeAl_3$	Purplish gray.	Needles.	Tendency to purple tinge with relief polishing.
Other iron constituents	Purplish gray.	"Chinese script" and needles.	Less tendency to purplish tinge. Occurrence due to other elements, notably Si. Composition uncertain.
$CuAl_2$	Clear with pink tinge.	Gobs, stringers.	Tendency to polish in relief and tarnish. Appears bright on passing out of focus.
$MnAl_3$	Flat gray to watery.	Angular plates, often hollow. Arrowheads.	Does not polish in relief, but prolonged polishing gives watery appearance. In high-manganese alloys shapes are very characteristic.
Mg_2Al_3	Very faint watery.	Gobs, stringers.	Same form as $CuAl_2$ but much softer. Sometimes difficult to distinguish from aluminum matrix.
$NiAl_3$	Light gray.	Needles.	Difficult to distinguish from $FeAl_3$.
Mg_2Si	Slate gray to iridescent blue.	Skeletons and rounded particles. Angular primary particles.	Very careful polish gives even slate-gray particles which are easily tarnished and are turned black or eaten out by too much water in polishing.

"With a little experience in the examination of specially prepared known standards, the identification of these constituents when they occur in sufficiently large particles is relatively simple and etching reagents for distinguishing them are generally unnecessary. When the particles are smaller, the identification becomes extremely difficult, but etching reagents which satisfactorily color large particles, fail to identify the smaller particles.

"In studying a specimen containing very small particles, such as finely precipitated $CuAl_2$, there may be sufficient surface flow to completely obscure the particles. To guard against this condition and to reveal grain boundaries and other structural features, it is desirable to swab the specimen lightly with a soft cotton swab saturated with a dilute solution of HF (0.5 to 1-per-cent preferred)."

Referring to page 1170, under the heading "Solutions for Aluminum and Its Alloys," the following list of etching reagents should be given, together with the specific use and the authority for the information:

	Reagent	Concentration	Specific Use	Authority	Reference Number
No. 1	HF and HCl[a]	10 to 20-per-cent alcoholic HF and concentrated HCl	Macroscopic	Czochralski	(1)
No. 2	HF and HCl[a]	10 parts HF, 15 parts HCl, 90 parts H_2O	Macroscopic	Flick	(13)
No. 3	HF	0.1 to 10-per-cent	General	Various	(2, 3, 4, 5, 6, 7, 11, 12, 14, 15, 16)
No. 4	NaOH	0.1 to 10-per-cent	General	Various	(2, 3, 4, 5, 6, 7, 11, 12, 14, 16)
No. 5	NaOH	0.1 per cent in 10 to 50 per cent of alcohol	General	Merica	(6, 7)
No. 6	HNO_3	1 per cent in alcohol	Mg_2Al_3	Hanson	(5)
No. 7	HNO_3	10 per cent in alcohol	Mg_2Al_3	Hanson	(5)
No. 8	HNO_3[b]	20-per-cent Quench	$CuAl_2$	Hanson	(5)
No. 9	HNO_3[b]	25-per-cent Quench	"X" Const. from $FeAl_3$	Dix	(9)
No. 10	Ferric sulfate	10-per-cent	$CuAl_2$ from $FeAl_3$	R. J. Anderson	(12)
No. 11	Picric acid	4 per cent in alcohol	$CuAl_2$	A. Meyer	(10)
No. 12	H_2SO_4[b]	10-per-cent at 60 to 70° C.	$FeAl_3$	A. Meyer	(10)

[a] Czochralski originally etched for grain by using from 10 to 20 per cent of concentrated HF in 100 cc. absolute alcohol, followed by dipping in concentrated HCl solution. Flick has very satisfactorily modified this etch by using a single solution prepared as follows: 10 cc. of commercial HF and 90 cc. of distilled water and 15 cc. of concentrated HCl.

[b] By the 20 and 25-per-cent nitric acid quench is meant the procedure of heating the solution to exactly 70° C. and immersing the specimen for a period from 2 or 3 seconds to 30 seconds and then immediately quenching the specimen in cold water. This same procedure may be used with the sulfuric acid etch, although the quench is not essential

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(4) Anderson, R. J., "Metallography of Aluminum," *Journal*, Franklin Inst., p. 187, 1 (1919).

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(6) *Circular No. 76*, U. S. Bureau of Standards (1919).

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(8) Dix, E. H., Jr., "Polishing Aluminum and Its Alloys for Metallographic Study." *Chemical and Metallurgical Engineering*, XXVII, 25, p. 1217 (Dec. 20, 1922).

(9) Dix, E. H., Jr., "Observations on the Occurrence of Iron and Silicon in Aluminum," *Proceedings*, Am. Inst. Mining and Metallurgical Engrs., LXIX, 957 (1923).

(10) Meyer, A., "Etching Reagents for Distinguishing Between Constituents in Aluminum Alloys," *Zeitschrift Metallurgie*, 15, p. 257 (September 1923).

(11) Daniels, S. D., "Cast Alloys of Aluminum Containing Small Amount of Magnesium," *Industrial and Engineering Chemistry*, 16, p. 1243 (December, 1924).

(12) Anderson, R. J., "Metallurgy of Aluminum and Aluminum Alloys," Baird and Co. (1925).

(13) Flick, F. B., "Etching Aluminum and Its Alloys for Macroscopic and Microscopic Examination," *Transactions*, Am. Inst. Mining and Metallurgical Engrs. (February, 1925).

(14) Dix, E. H., Jr., "A Note on the Microstructure of Aluminum-Iron Alloys of High Purity," *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part II, p. 120 (1925).

(15) Daniels, S. D., "Sand-Cast Aluminum-Manganese Alloys," *Industrial and Engineering Chemistry*, 18, p. 2 (February, 1926).

(16) Dix, E. H., Jr., and Richardson, H. H., "Equilibrium Relations in Aluminum-Copper Alloys of High Purity," Am. Inst. Mining and Metallurgical Engrs. (February, 1926).

Respectfully submitted on behalf of the sub-committee,

WILLIAM CAMPBELL,
Chairman.

APPENDIX

SOLUTIONS FOR CARBIDES, ETC., IN ALLOY STEELS

By E. C. Groesbeck[1]

Reagents

The formulas for several of the solutions mentioned below are as follows:

Alkaline sodium picrate (*Kourbatoff*).—2 g. of picric acid, 98 cc. of 25-per-cent NaOH in water.

NaOH solution—H_2O_2 mixture (*Yatsevitch*).—2 parts (by volume) of 10-per-cent NaOH in water, 1 part of H_2O_2 (commercial).

Alkaline potassium ferricyanide (*Murakami*).—10 g. of potassium ferricyanide, 10 g. of potassium (or sodium) hydroxide, 100 cc. of water.

Alkaline potassium permanganate (*Bureau of Standards*).—4 g. of potassium permanganate, 4 g. of sodium (or potassium) hydroxide, 100 cc. of water.

Etching

Two types of etching are covered: (*a*) simple immersion, and (*b*) electrolytic.

In method (*a*), the specimen is immersed in the etching solution at either room or boiling hot temperature, as indicated.

In method (*b*), the specimen is made the anode and a platinum electrode the cathode of an electric circuit. A very weak current, about 0.1 ampere per sq. cm., is used.

Remarks

The following remarks concern the nature of several of the constituents considered:

Cr-carbide.—Since there appears to be a lack of agreement regarding the nature and composition of the carbide found in chromium steels (reported in the literature either as simple or "double carbide," the latter containing varying amounts of cementite combined with one form or another of chromium carbide), it seems advisable to designate, for the present the carbide occurring in any type of chromium steel by a general term such as "chromium carbide" without indicating whether or not it is a simple or double carbide. If it be true that the cementite is combined with chromium carbide in varying amounts and knowing that these two constituents act differently in certain etching reagents, a difference in the etching behavior of the double carbide should be expected, according to the preponderance of the cementite or chromium carbide present; Murakami[2] implied that this was the case, though this does not seem to agree with the author's observations that the carbide particles in chromium steels of widely different chromium and carbon content behaved similarly towards the etching reagent.

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[1] Division of Metallurgy, U. S. Bureau of Standards, Washington, D. C.

[2] *Science Reports*, Tôhoku Imperial University, Japan, Vol. 7, p. 217.

WC (*tungsten carbide, or tungsten monocarbide*).—This is the constituent referred to by Hultgren as "X carbide" and later determined as WC (see pages 44, 51 and 60 of his book "A Metallographic Study on Tungsten Steels"). This constituent is found present in steels of sufficiently high tungsten and carbon content, and has a definite, easily recognized crystallin (triangular and rectangular) form. The etching effects referred to below are those produced on this type of constituent.

V-carbide.—It would appear that the formula for vanadium carbide (V_4C_3) and the manner of formation, as advanced by Arnold and Read[1] has remained unquestioned. Two vanadium-iron-carbon alloys, prepared at the U. S. Bureau of Standards and containing 11 to 12 per cent V and 2.8 per cent C, showed in the microsection numerous small to good sized, more or less rounded hard particles scattered throughout this matrix; there was no other constituent found present, hence Arnold and Reed's statement regarding the sole existence of vanadium carbide above a definite vanadium and carbon content seems to be confirmed. The usually low vanadium content in commercial steels containing vanadium should not offer opportunity for making etching tests for vanadium carbide.

Fe_2W.—Ozawa's work[2] confirms the conclusions reached by certain previous workers that this is the correct formula for iron tungstide.

High-Speed Steel Constituent.—It is evident from the literature on high-speed steels that there is a lack of uniformity in the appellations given to the globular particles found in the microsection of forged and heat-treated high-speed steels; they have been referred to as "carbide," "double carbide," "iron-tungsten carbide," "tungstide," etc. Since the true nature and composition of this constitutent has not yet been established, it appears advisable, for the present, to designate it by some general term. The writer has used the term "high-speed steel constituent" in the following tabulation.

In this tabulation there are included, besides the usual constituents met with in each class of steels, other constituents that might possibly be present under special conditions of chemical composition and heat treatment.

I. CARBON STEELS.

(*a*) *Simple Immersion.*—

1. Alkaline sodium picrate, 10-per-cent NaOH (or KOH) in water, alkaline potassium ferricyanide, or alkaline potassium permanganate. Use hot 5 to 10 minutes. Fe_3C attacked.

2. Neutral sodium picrate (Matweieff) in water. Use hot; 20 minutes. Iron phosphide attacked; cementite unattacked.

II. CHROMIUM STEELS

(ALSO CHROME-VANADIUM, CHROME-TUNGSTEN STEELS, FERROCHROME, ETC.)

(*a*) *Simple Immersion.*—

1. Alkaline potassium ferricyanide or alkaline potassium permanganate. Use hot; 1 minute. Cr-carbide, and WC attacked; Fe_3C and V-carbide more slowly attacked. No positive distinction between any of these constituents offered by these solutions.

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[1] *Journal*, Iron and Steel Institute, Vol. 85, p. 215, 1912.

[2] *Science Reports*, Tôhoku Imperial University, Japan, Vol. 11, p. 333.

(*b*) *Electrolytic.*—

1. Normal solution of an alkaline salt of a weakly dissociated acid, as oxalic, citric, acetic, or carbonic acid; 1 to 2 minutes. Cr-carbide, V-carbide and WC attacked; Fe_3C unattacked.

2. 1-per-cent NaOH, KOH or NH_4OH; 1 to 2 minutes. Cr-carbide, V-carbide, and WC attacked; Fe_3C attacked in 5 to 30 minutes.

III. TUNGSTEN STEELS

(FERRO-TUNGSTEN, ETC. SEE CHROMIUM STEELS FOR CHROME-TUNGSTEN STEELS)

(*a*) *Simple Immersion.*—

1. Alkaline potassium ferricyanide, or alkaline potassium permanganate. Use hot; 15 to 60 seconds. WC and Fe_2W attacked; Fe_3C more slowly attacked (3 to 10 minutes).

2. Alkaline sodium picrate, or 10-per-cent NaOH (or KOH) in water. Use hot; 5 to 10 minutes for Fe_3C and 1 minute for Fe_2W. Fe_2W and Fe_3C attacked; WC unattacked.

3. NaOH solution – H_2O_2 mixture. Use fresh; 1 to 5 minutes. Fe_2W attacked; Fe_3C and WC unattacked.

4. Neutral sodium picrate in water. Use hot; 1 minute. Fe_2W attacked; Fe_3C and WC unattacked.

(*b*) *Electrolytic.*—

1. Normal solution of an alkaline salt of a weakly dissociated acid, as citric, acetic, or carbonic acid; 1 to 2 minutes. WC particles attacked; Fe_3C and Fe_2W unattacked.

IV. VANADIUM STEELS

(SEE CHROMIUM STEELS FOR CHROME-VANADIUM STEELS)

Electrolytic.—

1. Normal solution of alkaline salt of a weakly dissociated acid, as citric, acetic, or carbonic acid; 2 minutes. V-carbide attacked; Fe_3C unattacked.

2. 10-per-cent sodium cyanide in water; 2 to 3 minutes. Cr-carbide attacked but V-carbide unattacked, hence possible distinction between V-carbide and Cr-carbide.

V. HIGH-SPEED STEELS

(*a*) *Simple Immersion.*—

1. NaOH solution – H_2O_2 mixture. Use fresh; 5 to 10 minutes. High-speed steel constituent and Fe_2W attacked; Fe_3C, Cr-carbide, WC, or V-carbide unattacked.

2. Alkaline sodium picrate. Use hot; 2 minutes. High-speed steel constituent and Fe_2W attacked; Fe_3C fully attacked in 5 to 10 minutes; Cr-carbide, WC, or V-carbide unattacked.

(*b*) *Electrolytic.*

1. Normal solution of alkaline salt of a weakly dissociated acid, as acetic acid, etc; 2 minutes. High-speed steel constituent, Fe_2W, and Fe_3C unattacked; Cr-carbide, WC, and V-carbide attacked.

2. 10-per-cent NaOH in water; 1 to 2 minutes. High-speed steel constituent, Fe_2W, WC, Cr-carbide attacked; V-carbide slowly attacked; Fe_3C unattacked.

REPORT OF SUB-COMMITTEE V ON MICRO-HARDNESS

Purpose of Tests

A statement concerning the origin and purpose of this sub-committee, in the report of Committee E-4 for 1923, reads as follows:

> "The Sub-Committee on Micro-Hardness is making a study of methods for obtaining the 'scratch' or 'scoring' hardness, making use of the instrument recently described by C. H. Bierbaum[1] for this purpose."

This instrument, essentially, consists of the mechanical stage of a microscope by means of which the polished surface of the specimen to be tested, which is firmly clamped on the stage, is moved horizontally beneath a "jewel point." The "point," which is made of an artificial sapphire (fused Al_2O_3) accurately ground into the form of the corner of a cube, is attached at one end of a balanced "jewel arm" which is pivoted into the adjustable jewel bracket. The point is mounted so that the diagonal of the cube is normal to the surface of the specimen to be tested and one edge of the cube is the cutting edge and advances directly in the line of motion of the specimen. The jewel arm carries a spirit level at the end opposite the point and a weight of 3 g. directly over the point. This weight is held directly above the point but not in contact with it. The cut is made through a drop of oil, such as cedar oil, on the polished surface of the specimen by rotating the micrometer feed arm by hand. Many other fine adjusting devices are necessary for the operation of the instrument but are not described here.

No other form of instrument for carrying out this test is commercially available, hence, the work of the sub-committee was limited to a study of the results which may be obtained with this particular type of instrument.

Tests Carried Out by the Sub-Committee

Tests on "Cutting" Speed:

In making determinations of micro-hardness with this instrument, the condition which may be most variable for different operators, assuming that the instrument is in good mechanical working condition, is the speed at which the specimen is drawn under the cutting point. A series of determinations were made at the U. S. Bureau of Standards with several different metals in which the speed was varied from a slow one obtained by turning the micrometer feed arm by hand at 30 or 36 r.p.m. to one of 360 to 420 r.p.m. obtained by means of a small auxiliary motor drive. The results obtained under these conditions are summarized in Table I:

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[1] C. H. Bierbaum, "A Study of Bearing Metals," *Transactions*, Am. Inst. Mining and Metallurgical Engrs., Vol. 69, p. 972 (1923).

TABLE I.—EFFECTS OF CUTTING SPEED ON RESULTS OF MICRO-HARDNESS TEST.

Material	Relative Cutting Speed, r. p. m.[a]	Width of Cut, micron[b]		
		Maximum	Minimum	Average
Antimony	36	9.02	8.28	8.73
Antimony	360	9.86	8.09	8.84
Cobalt	36	4.46	2.79	3.53
Cobalt	360	4.56	2.88	3.60
Copper	30	12.65	10.42	11.22
Copper	420	12.09	10.23	11.25
Tin	30	29.39	27.16	28.15
Tin	420	28.83	27.16	28.00
Tin-antimony alloy (crystals)	30	9.49	7.25	8.50
Tin-antimony alloy (crystals)	480	9.02	7.81	8.29
Tin-antimony alloy (matrix)	30	22.69	20.37	21.53
Tin-antimony alloy (matrix)	480	22.23	21.20	21.52

[a] Rotations of crank arm of the micrometer feed.
[b] Ten determinations in each case, except five for the tin-antimony alloy matrix.

From the results of Table I, it may be concluded that pronounced variations in the cutting speed in making micro-hardness tests of a metal which is of essentially the same hardness throughout such as a "pure" metal or a single phase alloy will not appreciably influence the average results. The variations in the width of any cut made at a constant cutting speed were found to be greater than the differences produced by the pronounced change in cutting speed. The variations in width of cut appear to bear no very significant relation to the speed at which the cut was made. As a rule, however, as is shown in the table, a somewhat more uniform average cut was made by operating at the higher speed.

It is not to be concluded, however, that the cutting speed is an entirely negligible factor. In determining the hardness of small particles of a "foreign impurity" or of an alloy constituent embedded in a matrix of different hardness (usually lower) from that of the particles under observation, the speed at which the point is drawn over the surface is of very considerable importance. A tendency for the point to dodge around a small hard particle instead of cutting across it was observed in some of the tests with the instrument. The importance of a slow uniform rate in the motion of the point in testing such a material is obvious.

Cooperative Tests, First Series:

In the first series of measurements carried out by the subcommittee, a set of eleven metals as unknown samples was used in turn by several different members. The results obtained were given in the report of Committee E-4 for 1925. They are also included in this report in graphic form (Fig. 1) for purpose of reference. These results, obtained by six observers, are representative of four different instruments, since three of the observers used the same instrument. The differences in the results for these three observers for any particular material (represented by the full black circles in Fig. 1) therefore, are to be regarded as indicating "personal" errors rather than differences attributable to the instrument. It will be noted from Fig. 1, in which the metals are arranged approximately in order of decreasing hardness, that the agreement for these three observers who used the same instrument is much better for the harder materials than for the softer ones. This is also true for the measurements made by the other three observers. This fact suggests that the personal error in making the measurements shown in Fig. 1 predominated over instrumental errors.

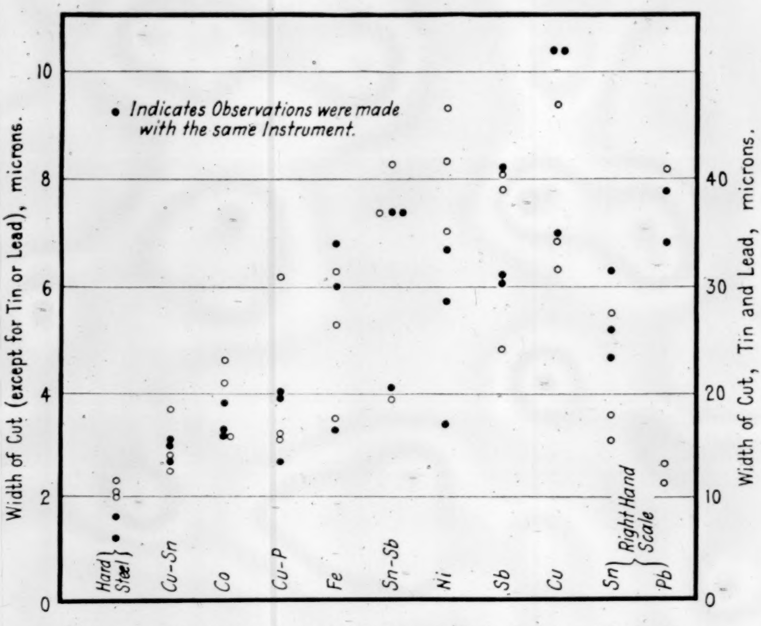

FIG. 1.—Results of Scratch-Hardness Tests on Eleven Metals, as Obtained by Six Observers.

Cooperative Tests, Second Series:

In the second set of hardness measurements carried out by the sub-committee, two metals in sheet form, cold rolled to various degrees of hardness as shown by Brinell hardness measurements, were used. These were commercial sheet aluminum and soft, that is, low-carbon, steel sheet. Small pieces cut from the same piece of sheet metal were distributed to the same sub-committee members who had cooperated in the work described in the preceding section. Because of the skill required in polishing aluminum for metallographic tests in general, all of the aluminum specimens were polished before distribution[1] and were ready for use. When the specimens were distributed, the request was made that in determining the hardness of these cold-rolled metals, the micro-cut be made in three directions, (1) parallel to the rolling direction, (2) at 90 deg. to the rolling direction, and (3) diagonally, that is, 45 deg. to the direction of rolling. Reports were received from four of the members to whom the specimens were submitted; two of the four returned complete reports, the other two partial ones giving averages only. The average results are shown graphically in Fig. 2.

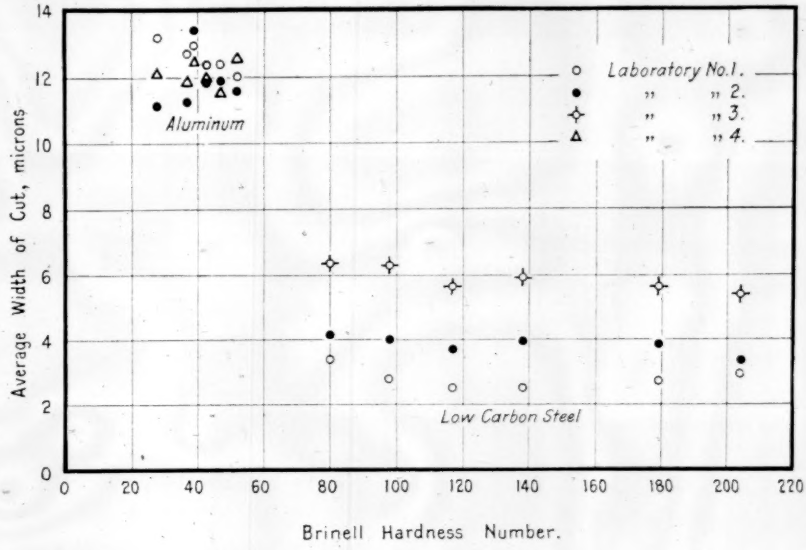

FIG. 2.—Hardness of Cold-Rolled Aluminum and Cold-Rolled Steel by the Scratch Method.

The variations in the width of the cut on the polished metal surface in some cases are of very considerable magnitude. Hence, the average width of cut reported should be based upon a considerable number of measurements. Each point in Fig. 2 for Laboratories 1 and 2 represents 30 readings. As a rule, 10 measurements of the cut in each of the three directions were made. It is believed that the agreement in the hardness determinations as made by the two laboratories submitting complete reports is as close as can be expected in determinations of this kind. In the measurements of the width of cut, the attempt was made by these two laboratories to measure only the true cut, that is, to exclude the distorted metal which usually borders the cut on each side.

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[1] This was done by E. H. Dix, Jr., a member of the sub-committee.

Although the primary aim of the tests reported here was not to correlate Brinell hardness with micro-hardness, the results, incidentally, do give some information on this point. It is evident from Fig. 2 that a pronounced difference in Brinell hardness, produced by cold rolling, results in only a very slight change in the micro-hardness. No consistent variation in the width of the cut according to the direction in which it was made, with respect to the rolling direction of the sheet, was detected, although there appears to be a slight tendency for this method to show a somewhat lower micro-hardness for a cold-rolled metal when the cut is made parallel to the direction of rolling than when made at an angle of either 45 or 90 deg. to the rolling direction.

CONCLUSIONS

The finishing of the tests reported here marks the completion of the program outlined by the sub-committee on the determination of the micro-hardness of metals. The sub-committee offers the following as its conclusions concerning this method of testing:

1. The method obviously in its present form is not capable of much accuracy. Differences in the results reported by different observers using the same instrument with the same specimens ranged from 10 to 50 per cent. For useful comparisons the average of at least ten readings should be taken.

2. In measuring the width of the cut made by the point, it is recommended that the "fringe" of distorted metal usually found on each side of the cut be disregarded. The width of the cut may be measured directly with a suitable scale after projecting the image on the ground-glass screen of the microscope at a known magnification, or a properly calibrated micrometer ocular may be used.

3. The test is not suitable for revealing the work hardness of cold-rolled metals. A pronounced difference in hardness as shown by Brinell hardness tests of a metal after varying degrees of cold rolling

resulted in only a slight change in the hardness as determined by the scratch method.

4. In spite of these difficulties, the method is very useful in showing differences in the hardness of the different constituents of a heterogeneous material and is the only available method for this purpose.

Respectfully submitted on behalf of the sub-committee,

H. S. RAWDON,
Chairman.

APPENDIX

BIBLIOGRAPHY OF SCRATCH-HARDNESS METHODS AS APPLIED TO METALS

There is given below, for purpose of reference, a quite complete annotated bibliography on the method of scratch-hardness testing.

No. YEAR REFERENCE

(1) 1886 Turner, Thomas, "Hardness of Metals," *Transactions*, Birmingham Phil. Soc. 5, part 2.

To Turner belongs the credit of extending the scratch-hardness method, previously used for minerals, to metals and alloys.

(2) 1890 Martens, A., "Untersuchung dreier Härteprüfer," Mitteilungen, Könichliche Technische Versuchs-Anstalt 8, 215.

Martens improved Turner's method and developed his well-known sclerometer.

(3) 1899 Martens, A., "Handbook of Testing Materials," *Transactions*, G. C. Henning, Vol. 1, p. 299.

The load on a 90 deg. conical diamond point required in order to produce a cut on the polished surface of the metal specimen averaging 0.01 mm. in width was defined as the "scoring" hardness number (H_s).

(4) 1908 Meyer, Eugen, "Untersuchungen über Härteprüfung und Härte," *Zeitschrift*, ver. deuter Ing. 52, pp. 645, 740, and 835.

A very comprehensive analytical study of the various methods for determining hardness. For a conical point used in scratch-hardness tests, Meyer developed a formula for the "specific resistance" (pr) of any particular metal to the scoring of the surface by the point: $pr = \frac{2P}{\frac{\pi}{4} d^2}$ in which P is the load applied and d the width of the cut (d includes the border of deformed metal on each side of the true cut). In order to obtain pr from Martens' value (H_s) for scratch-hardness, that is, the load necessary to give a cut 0.01 mm. wide, Martens' number must be multiplied by the constant 25.5. Meyer gives results for a series of metals and also curves showing the variation in scratch-hardness with varying loads (compare Ref. 16). Curves for the comparison of "ball-hardness" and "cone-hardness" with scratch-hardness are also given.

(5) 1909 Pöschl, V., "Die Härte der festen Körper," Dresden.

Martens' sclerometer was improved and fitted to the stage of the microscope.

NO. YEAR REFERENCE

(6) 1914 Heathcote, H. L., "An Improved Sclerometer," *Iron Trade Review*, 54, 843.

A shop method of applying the "file test" especially for case-hardened steel.

(7) 1918 Craggs, J. W., "Notes on Testing Hardness of Metals," *Journal*, Soc. Chemical Industry, 37, p. 43T.

Reference to Turner and to Martens is made in the summary of hardness testing methods. The experience necessary in carrying out Turner's test is emphasized.

(8) 1919 Hadfield, Sir R. A., and Main, S. A., "Note on Brinell and Scratch-Hardness for Hardened Steel," *Proceedings*, Inst. Mechanical Eng., Part 2, p. 581.

Results obtained by the Brinell method and scratch hardness method on a series of steels. An approximate formula was developed giving the relation between the Brinell hardness number and H_s in terms of w^3, w being the width of cut. Hadfield and Main concluded that the scratch test may measure some aspect of hardness different from that measured by the Brinell test.

(9) 1919 Unwin, W. C., "The Brinell and Scratch Test of Hardness," *Engineering*, 108, p. 669.

Discussion of data in Ref. **8.** Unwin concludes that formula for the scratch-hardness numbers (H_s) should be of the form $\frac{BP}{w^2}$, B being a constant, P the pressure, and w the width of the scratch. If a constant pressure is used, then H_s is proportional to $\frac{1}{w^2}$.

(10) 1919 Leslie, R. M., "Brinell and Scratch Tests of Hardness," *Engineering* 108, p. 797.

Leslie discusses the date of Ref. **10** and cites some experience of his own. He concludes that scratch-hardness tests "form an excellent secondary method of testing to within 6 or 8 per cent, but for actual measurement as a fundamental method, it is impracticable."

(11) 1920 Bierbaum, C. H., Capp, J. A., and Diedericks, H., Report of Sub-Committee on Bearing Metals. (The Microcharacter at Work), *Transactions*, Am. Soc. Mechanical Engrs. 42, p. 1099; also *Iron Age*, 106, p. 1727.

A description is given of the instrument developed, termed the microcharacter (from two Greek words: to engrave, small). This is the form of instrument used by Sub-Committee V of Committee E-4 in its work.

(12) 1920 Berndt, G., "Scleroscopic, Ball-Pressure and Scratch-Hardness," *Werkstattstechnik*, 14, p. 201.

No.	Year	Reference
(13)	1921	Bierbaum, C. H., Capp, J. A., and Diedericks, H., Report of Sub-Committee on Bearing Metals, *Transactions*, Am. Soc. Mechanical Engrs. 43, p. 1273.
(14)	1923	Bierbaum, C. H., "A Study of Bearing Metals," *Transactions*, Am. Inst. Mining and Metallurgical Engrs. 69, p. 972. Application of the "microcharacter" to the study of bearing alloys for determining the relative hardness of the different constituents.
(15)	1923	Bellis, A. E., *et al.*, "Symposium on Hardness Testing," *Transactions*, Am. Soc. Steel Treating, 3, p. 480. A brief mention of the method in the general discussion of hardness methods.
(16)	1923	Hankins, G. A., "Relation Between Width of Scratch and Load on Diamond in Scratch-Hardness Tests," *Engineering*, 115, p. 537. In a series of tests at the National Physical Laboratory, Hankins investigated the effect of shape of point (diamond) and of load on the resulting scratch hardness number. A linear relationship was reported for L with w (w^2 being width of scratch, L the load). Hankins suggests making use of the slope of the line as a measure of the hardness. Lines obtained with the same point for different metals have different slope but pass through the same point (approximately). Hankins suggests that the scratch test measures a property slightly different from that measured by the Brinell method.
(17)	1923	Ries, A., and Zimmerman, L., "Hardness and Hardness Anisotropy," *Zeitschrift*, Krist. 57, pp. 449–557. An excellent historical account of the scratch hardness method especially as applied to minerals is given.
(18)	1925	Shires, G. A., "Some Practical Aspects of the Scratch Test for Hardness," *Proceedings*, Inst. Mechanical Eng., No. 3, Vol. 1, p. 647; also *Engineering*, 119, 557. Shires concludes that the method is valuable for measuring the hardness of pieces too small for the regular ball-indentation test and for showing up local variations in hardness, such as in the different constituents of an alloy, which the ordinary method misses entirely.

REPORT OF SUB-COMMITTEE VI ON X-RAY METALLOGRAPHY

Sub-Committee VI is submitting for publication as tentative a Recommended Practice for Radiographic Testing of Metal Castings appended hereto.[1] This has been prepared by H. H. Lester of the Watertown Arsenal.

A glossary of terms relating to metallography prepared by L. W. McKeehan of the Bell Telephone Laboratories is appended to this report. This glossary, though incomplete, is offered in the hope that it may assist those not specialists in the subject to understand papers in this branch of technology, and in the further hope that it may guide specialists, in writing such papers, to use well-known words and those which, in the opinion of the sub-committee, are on the way to becoming standard. In matters of spelling the Standard Dictionary (Funk and Wagnalls) has been followed. The use of the hyphen is recommended in many cases where it may seem superfluous. The sub-committee feels, however, that using a series of nouns as a single substantive should be avoided in English composition. The hyphen calls needed attention to the awkwardness of such a construction and invites the substitution, at a later date, of a simpler and better form.

Respectfully submitted on behalf of the sub-committee,

ZAY JEFFRIES,
Chairman.

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[1] See p. 1093.—ED.

APPENDIX

GLOSSARY OF TERMS RELATING TO X-RAY METALLOGRAPHY

By L. W. McKeehan[1]

Å—Ångström unit, 10^{-8} cm.

absorber (for X-rays).—A sheet of matter which reduces the intensity of X-radiation reaching the measuring or detecting device while permitting X-rays of desired type to produce an effect. When depending upon selective absorption the absorber is usually called a filter (*q. v.*).

absorption coefficient (of X-rays).—The rate of decrease, per unit distance traversed, of the natural logarithm of the intensity of a parallel beam; usually written μ.

amorphous.—Without crystal structure.

anisotropic.—Having different properties in different directions.

anticathode (of X-ray tubes).—The part of the anode which receives most of the cathode-rays.

asterism (of X-ray diffraction-patterns).—The appearance of strongly marked streaks or bands along radii of the pattern.

axial (in crystals).—Parallel to a principal axis, or, if the three principal axes are not equivalent, parallel to that principal axis about which the symmetry is highest. (in wires and rods).—Parallel to the axis of figure.

axial ratio (in crystals).—In the tetragonal system and in the hexagonal division of the hexagonal system, the ratio of the parameter for the principal axis of highest symmetry to the parameter for any one of the other axes, usually written $C = c/a$; in less symmetrical systems the ratio of all three parameters; usually written $a : b : c$.

axis (in crystals).—One of three intersecting lines which meet any possible crystal face at points whose distances from their intersection, in terms of three parameters, one for each axis, are in the ratios of small integers; the principal axes are those about which the symmetry is the highest possible to the crystal considered.

beam (of X-rays).—A nearly parallel group of rays from a common source.

body-centered (space-lattice).—Having equivalent points at the corners of the unit cell, and at its center; sometimes called centered, or space-centered.

Bragg (method of X-ray or crystal analysis).—Using monochromatic or polychromatic X-rays and a single crystal of large size rotated about an axis lying in a crystal face.

bulb (in X-ray tubes).—The glass (or other pressure-tight) part; when of metal, more usually called the body.

calcite.—Natural rhombohedral $CaCO_3$, the primary standard crystal used in X-ray spectrometry.

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[1] Bell Telephone Laboratories, Incorporated, New York City; member of Sub-Committee VI, of Committee E-4, on X-ray Metallography.

cassette (in X-ray spectrographs).—A box for holding a photographic film or plate in position to receive the diffraction pattern.

channel (in X-ray spectrographs).—A collimating system consisting of a hole of uniform cross-section through a thick piece of metal (usually in two parts to permit cleaning).

chaotic orientation (of crystals in an aggregate).—Orientation at random, all orientations being equally probable.

characteristic X-rays.—Series of monochromatic X-rays superposed on the general X-radiation emitted by a particular element when exposed to cathode-rays (or X-rays) of sufficiently high velocity (or frequency).

close-packed (atomic arrangement in crystals).—Having one of the two possible arrangements in which equal hard spheres can be made to occupy the least volume, and, by extension, having any of the hexagonal arrangements derived from one of these by expansion or contraction of the hexagonal axis.

collimate.—To isolate a parallel, or nearly parallel, beam of rays, as by slits, pinholes, or a channel.

continuous spectrum.—Same as heterochromatic X-rays.

Coolidge (X-ray tube).—Having a high vacuum and a hot-wire cathode.

critical (voltage, wave-length or frequency).—With respect to a particular element, dividing values which can excite characteristic X-rays from values which cannot; discontinuities in absorption of X-rays also occur at such critical or limiting values.

crystal.—A continuous piece of matter all parts of which have the same anisotropic arrangement of atoms; in metals sometimes synonymous with grain and crystallite.

crystal (adjective).—Of, or pertaining to, crystals.

crystal unit.—Same as unit of structure.

crystallin.—Composed of crystals.

cross direction (in rolled metal).—The direction parallel to the axes of the rolls at the moment of deformation.

crystallogram.—A photographic record of an X-ray diffraction-pattern produced by a crystal.

cube-centered (space-lattice).—Same as body-centered cubic.

cubic (crystal).—Having three equivalent axes at right angles; sometimes called isometric.

dashed (X-ray diffraction-pattern from a crystal aggregate).—Made up of separately distinguishable diffraction-images of the source.

Debye (method of X-ray crystal analysis).—Using a monochromatic (or polychromatic) X-ray beam defined by pinholes, an aggregate of small crystals oriented more or less completely at random and a photographic film bent almost completely around a cylinder; compare Hull method; sometimes called powder method.

define (X-rays).—To limit in angle, as by slits or pinholes; to collimate.

deviation (of X-rays).—The angle between the direction of incidence (produced through the crystal) and the direction of diffraction; twice the glancing angle of incidence; usually written 2θ.

diagram (of X-ray diffraction-patterns).—A representation, either a photograph as taken, or a projection therefrom; as, the index diagram.

diamond-cubic (atomic arrangement).—Similar to the diamond in having two face-centered cubic arrangements of atom-centers either of which is displaced with respect to the other by one-fourth of the cube diagonal.

diffraction (of X-rays).—The deviation of a beam by scattering from atoms which have some regularity of arrangement or spacing.

diffraction pattern (of X-rays).—The totality of the traces, on a plane or other known surface, of the beams diffracted by a crystal or by a crystallin aggregate.

doublet (of characteristic X-rays).—A pair of lines which differ little in wave-length, *e. g.* the $K\alpha$-doublet, $K\alpha_1$ and $K\alpha_2$.

end-centered (orthorhombic space-lattice).—Having equivalent points at the corners of the unit cell and at the centers of one pair of its opposite faces.

equivalent (of points, lines, planes, atoms, etc., of a crystal).—Being interchangeable in the sense that allowable symmetry-operations effect the interchange.

excite (X-rays).—To cause to be emitted.

exposure (to X-rays).—The extent of excitation; with X-ray tubes of the same kind and operated at the same voltage exposure is measured by the product of the electron current through the tube by the time of excitation.

face (of crystals).—A natural surface, or a cut surface parallel to a possible natural surface.

face-centered (space-lattice).—Having equivalent points at the corners of the unit cell, and at the centers of its six faces.

fiber-diagram.—An X-ray diffraction-pattern indicating that the orientation of the crystals in an aggregate is not chaotic, but is preferred, being symmetrical about an axis, the fiber-axis (translation of "faserdiagramm").

filter (for X-rays).—A sheet of matter selectively absorbing secondary or other undesired X-rays.

fluorescent (X-rays).—Characteristic X-rays excited by X-rays.

fluorescent screen (for X-rays).—A sheet of matter (usually on paper) which emits visible or actinic light under X-ray excitation.

focus (in X-ray tubes).—The spot on the target whereon the cathode rays are concentrated and which is therefore the principal source of X-rays; its shape and size are controllable by design.

focusing (methods of X-ray or crystal analysis).—Using such a shape and position of sample that the diffracted X-rays from many (or all) of its parts fall close together in the diffraction-pattern; such methods permit the use of wide beams and require relatively short exposures.

form (of equivalent crystal planes).—Having the same indices, except for sign or order; *e. g.* the planes (110), (10$\bar{1}$) in a cubic crystal are both of the form $\{110\}$.

frequency (of X-rays).—Measured by the equation $\nu = c/\lambda$, wherein c is the velocity of propagation of light (3×10^{10} cm. per sec.) and λ is the wave-length in centimeters.

general (of X-radiation).—Same as heterochromatic.

glancing angle.—The angle between the incident X-ray beam and the crystal planes from which reflection takes place, however these may be inclined to the bounding surface of the crystal, usually written θ.

grain (in metal).—Same as crystal, but pseudo-grains may sometimes be seen when the real crystals are much smaller.

grating constant (in crystals).—Same as interplanar distance.

grating space (in crystals).—Same as interplanar distance.

halo (in X-ray diffraction patterns).—A broad and poorly defined circular band; as seen in the case of solids only for some of the alkali metals.

hard (X-rays).—Having great penetrating power, short wave-length, high frequency.

hemihedral (crystal).—Having different properties in opposite directions, or on opposite faces, or lacking a symmetrically opposite face.

heterochromatic (X-rays).—Having a continuous series of wave-lengths, as from a tube operated below its critical voltage.

heterogeneous (X-rays).—Same as heterochromatic.

hexagonal (crystal).—Having a sixfold axis of symmetry; there are three equivalent twofold axes in the plane at right angles to the sixfold axis.

homogeneous (matter).—Having the same properties in every small region containing many atoms (but not necessarily isotropic).

(X-rays).—Same as monochromatic.

Hull (method of X-ray crystal analysis).—Using a monochromatic (or polychromatic) X-ray beam defined by slits (or pinholes), an aggregate of small crystals oriented more or less completely at random and a photographic plate or a photographic film (if the latter, bent around a cylinder); compare Debye method; sometimes called powder method.

image (in X-ray diffraction-patterns).—By analogy with optics, a recognizable copy of the source of X-rays or of any aperture defining the X-ray beam.

indices.—See Miller indices, Miller-Bravais indices, line-indices.

intensifier (for X-rays).—A substance placed in, on, or under a photographic film or plate or a fluorescent screen, or used in the development of the photographic negative, to make the effects of X-rays more conspicuous.

intensifying factor (for X-ray intensifiers).—The ratio between the exposure time when no intensifier is used to the exposure time, for the same effect, when the intensifier is used, all other conditions remaining constant.

intensifying screen (in X-ray spectrographs).—A separately mounted intensifier.

interplanar distance (of crystals).—The perpendicular distance between the nearest equivalent planes of common Miller indices; usually written *d*.

ionization method.—Any method of X-ray or crystal analysis which depends upon measuring the conductivity of a gas exposed to the diffracted X-rays; great accuracy in angular measurement is possible but not easy.

isotropic.—Having the same properties in every direction.

K—Used to designate the characteristic X-rays of shortest wave-length; Greek letters and Arabic subscripts are used to distinguish the lines of the K-series; *e. g.* $K\alpha_1$ of copper, $K\beta$ of molybdenum; L, M, etc., are used to designate characteristic X-rays of greater wave-length, but these are rarely used in crystal analysis.

lattice.—Same as space-lattice.

Laue (method of crystal analysis).—Using heterochromatic X-rays, a small fixed crystal and a plane screen, usually a photographic plate: the Laue spot is the image (of a pinhole or of the small crystal itself) characteristic of the resulting diffraction-pattern.

limit (of voltage, wave-length or frequency of X-rays).—A value on the two sides of which excitation, absorption, photographic effect, or the like have sharply different values.

line (in X-ray spectra).—A group of monochromatic X-rays.

(in X-ray diffraction-patterns).—A straight or slightly curved narrow region of conspicuous intensity.

line focus (in X-ray tubes).—A focus (*q. v.*) with one dimension reduced to such an extent that the focus approximates to a segment of a straight line on the target in the plane determined by the tube axis and the direction from the target to the object. (This secures the advantages of a point source of X-rays without extreme local heating.)

line-indices.—The smallest integers proportional to the coordinate-differences, in terms of the parameters, between equivalent points lying on a possible crystal edge; written, in general $[HKL]$, in particular, *e. g.* [210]; in cubic crystals the line $[abc]$ is perpendicular to the plane (abc).

mass-absorption coefficient (of X-rays).—The rate of decrease, per unit mass traversed, of the natural logarithm of the intensity of a parallel beam; usually written μ/ρ.

mass-scattering coefficient (of X-rays).—The rate of decrease, per unit mass traversed, of the natural logarithm of the intensity of a parallel beam, due to scattering alone; usually written σ/ρ; the excess of the mass-absorption coefficient, μ/ρ, over σ/ρ is called the true mass-absorption coefficient, μ'/ρ.

Miller indices (of crystal planes).—The smallest integers proportional to the reciprocals of the intercepts, in terms of the parameters, of the plane on the three axes; written, in general, (hkl), in particular, *e. g.* (210); see form.

Miller-Bravais indices (of crystal planes in the hexagonal division only).—The smallest integers proportional to the reciprocals of the intercepts, in terms of the parameters, of the plane on the four axes; written in general $(hjkl)$, in particular, *e. g.* $(11\bar{2}0)$; the index for the hexagonal axis is always written last; $k = -(h + j)$ and may be replaced by a period, thus $(11\bar{2}0)$ and (11.0) are the same.

monochromatic (X-rays).—Having only a single wave-length.

monoclinic (crystal).—Having three non-equivalent axes, only one of which is at right angles to the other two.

order (of X-ray reflection).—The integral value of n in the equation $n\lambda = 2d\sin\theta$.

orientation (of crystals).—Arrangement in space of the axes of a crystal; every crystal must at every moment have a definite orientation, only aggregates, in space or in time, can possess chaotic orientation; if not chaotic some one or more orientations must be preferred.

orthorhombic (crystal).—Having three non-equivalent axes mutually at right-angles.

oscillating-crystal (methods of X-ray or crystal analysis).—Using a single crystal rotating at constant speed, but alternately in both directions, through less than a complete rotation.

parameter (of crystals).—The length of an edge of the unit cell, usually written a, b, or c; especially, in cubic crystals, the length of the edge of the unit cube, usually written a.

pinhole.—A small round hole used to define a beam of X-rays.

polychromatic.—Having several distinct wave-lengths, as, the characteristic X-rays from a single element.

powder (method of X-ray or crystal analysis).—Using a loose aggregate of small crystals with chaotic orientation; applied, early but somewhat illogically, to methods using solid metals composed of such aggregates; see Debye, Hull.

preferred orientation.—See orientation.

primary (X-rays).—Emitted directly from the focus in the X-ray tube.

principal (X-ray spectra in revolving-crystal methods).—Due to planes whose zone-axis is the axis of rotation of the crystal.

pseudocrystallin.—Possessing regularities of structure which result in a diffraction-pattern, although true crystals are not present, *e. g.*, stretched rubber, cellulose fibers.

radiography.—The use of X-rays in studying the macrostructure of single objects or assemblies (internal boundaries, inclusions, variations in density or composition, etc.).

random (orientation).—Same as chaotic.

rating (of X-ray tubes).—Product of allowable current and operating voltage (peak).

reflection (of X-rays).—Diffraction considered as due to scattering by crystal planes as units, these being the reflecting planes; monochromatic X-rays are reflected only when $n\lambda = 2d\sin\theta$, where n is order, λ, wave-length, d, interplanar distance, and θ, glancing angle.

revolving-crystal (methods of crystal analysis).—Using a small single crystal rotating uniformly throughout the exposure.

rhombohedral (crystal).—Having three equivalent axes equally inclined to each other, but not at right angles; a special case of, and included in, the hexagonal system.

rock salt.—Natural (cubic) NaCl, the secondary standard crystal used in X-ray spectrometry.

rolling direction.—In rolled metal, the direction, in the plane of the sheet, perpendicular to the axes of the rolls at the moment of deformation.

scattering (of X-rays).—The reemission of X-rays from an irradiated atom, without change of wave-length (except as modified by the Compton effect); it takes place in all directions with respect to the incident X-rays, but more intensely (or more often) in some directions than in others.

screen (in X-ray spectrographs).—A flat or curved surface on which a diffraction-pattern may be observed, as a fluorescent screen (*q. v.*); sometimes, but not so properly, a shield.

secondary (X-rays).—Emitted elsewhere than from the anticathode.

(X-ray spectra in revolving-crystal methods).—Due to planes whose sphenoid axis is the axis of rotation of the crystal; *cf.* primary.

series (of X-ray spectra).—A group of characteristic X-rays excited simultaneously in a single element; distinguished as *K*-series, *L*-series, etc.

shield (in X-ray spectrographs).—A metal plate, block, or the like, which prevents X-rays (usually secondary) from reaching the measuring or detecting device; a complete absorber (*q. v.*).

shutter (in X-ray spectrographs).—A shield which may be removed at pleasure.

side-centered (orthorhombic space-lattice).—Having equivalent points at the corners of the unit cell, and at the centers of two pairs of its opposite faces.

simple (space-lattice).—Having equivalent points only at the corners of the unit cell.

single-crystal (methods of X-ray or crystal analysis).—Using only one crystal and that one usually in known orientations.

slit.—A narrow opening with parallel sides, used to define a beam.

slit-system.—A series of slits used to define a beam and cut off secondary X-rays.

soft (X-rays).—Having long wave-length, little penetrating power, low frequency.

space-lattice (of crystals).—A system of equivalent points formed by the intersections of three sets of planes parallel to pairs of principal axes; the space-lattice may be thought of as formed by the corners of the unit cells.

spacing (of crystal planes).—Same as interplanar distance.

spectrograph (instrument for X-ray or crystal analysis).—An instrument using an extended surface—a photographic plate or film, or a fluorescent screen—for receiving the diffraction-pattern.

spectrometer (instrument for X-ray or crystal analysis).—An instrument using a measuring device for exploring the diffraction-pattern.

spectrum (of X-rays).—A distribution of X-rays along a line in accordance with wave-length, or a group of X-rays so distributable. (The set of parallel spectra furnished by the revolving-crystal method is sometimes called the complete spectrum.)

structure.—The arrangement of parts; especially, of crystals, the shape and dimensions of the unit cell and the number, kinds and positions of the atoms within it.

target (in X-ray tubes).—The part of the anticathode, wholly or predominantly of a single metal, or coated with a substance to be analyzed, where the focus lies.

tetragonal (crystal).—Having three axes mutually at right angles, only one of which is a fourfold axis.

transmission (methods of X-ray or crystal analysis).—Having the diffracted X-rays emergent from a surface on which no X-rays are incident.

triclinic (crystal).—Having three non-equivalent axes, no two at right angles.

uniform (X-ray diffraction-pattern).—Specifically, not dashed (*q. v.*).

unit cell (in crystals).—The least parallelopiped, which possesses the full symmetry of the crystal, and repetition of which in all directions builds up a crystal of any size.

unit cube.—The unit cell in cubic crystals.

unit of structure.—The group of atoms included by the unit cell, especially if the arrangement of the group indicates chemical relations between its members.

wave length (of X-rays).—Measured by the equation, $\lambda = \frac{2d\sin\theta}{n}$ wherein d is the interplanar distance in a crystal which reflects the X-rays at the glancing angle θ in the nth order.

wedge-spectrograph (instrument for X-ray or crystal analysis).—A spectrograph in which the beams of incident and diffracted X-rays are limited by a wedge brought into contact with the surface of the crystal; also called slitless spectrograph.

white (X-rays).—same as heterochromatic.

X—X-unit, 10^{-11} cm.

X-radiation.—X-rays in general, especially when direction of propagation is not emphasized.

X-ray (adjective).—Of or pertaining to X-rays.

X-ray tube.—An assembly of cathode, anticathode, and bulb (or body) suitable for the production of X-rays.

X-rays.—Rays, excited usually by the impact of cathode-rays on matter, which have wave-lengths, as defined by crystal reflection, between about 10^{-6} cm. and 10^{-9} cm.; also written x-rays; same as Röntgen rays.

zone-axis (in a crystal).—A line parallel to several crystal planes; the planes to which it is parallel form a zone.

DISCUSSION

Mr. St. John. MR. ANCEL ST. JOHN.[1]—In the Report of Sub-Committee VI on X-ray Metallography of Committee E-4 on Metallography is included a proposed Tentative Recommended Practice for Radiographic Testing of Metal Castings.[2] With most of this practice I am in hearty agreement. But I would call attention to a valuable alternative to the use of a lead-lined operating chamber as described. This consists in enclosing the X-ray tube within a lead case of suitable shape and dimensions to give ample high-tension insulation and X-ray protection, permitting the rays to pass through suitable windows so as to traverse the article to be examined, and absorbing any stray rays by suitably placed shields. When I first took up X-ray work twenty years ago I adopted this practice and have used it ever since. I have never injured myself or any one else through scattered radiations or otherwise, and have secured most satisfactory results in both radiography and fluoroscopy. This arrangement not only reduces the cost of an X-ray installation but also increases its flexibility as it is possible to transport the equipment from one place to another. Within the past week I have made radiographs in routine inspection with equipment which twenty-four hours previously was in operation in a building several miles distant. I suggest that reference to such practice be included in the recommendation.

Mr. Lester. MR. H. H. LESTER[3] (*Closure for Committee E-4, by letter*).—Mr. St. John's suggestion for a lead-lined container for the X-ray tube rather than a lead-lined room is interesting, though not novel. Such an arrangement was considered at one time for Watertown Arsenal, but the idea was discarded because it seemed to be impractical.

Perhaps an illustration will show, as well as can be done, some reasons why we have regarded the idea as unsuited to our work. We recently had to examine with the X-ray the lower half of a turbine shell weighing over 3000 lb. In order to get the pictures on this piece it was necessary to manipulate the tube extensively and at peculiar angles. To have gotten suitable positions for pictures by manipulating the casting would have entailed a great loss of time, would have taken a great deal of effort and would have necessitated keeping three or four laborers on the job. Besides these disadvantages,

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[1] Consulting Physicist, New York City.

[2] See p. 1093 —ED.

[3] Research Physicist, Watertown Arsenal, Watertown, Mass.

Mr. Lester. one position called for the placing of the X-ray tube between the inlet and outlet connections. This space was hardly large enough for the tube alone. A lead-lined cylinder large enough to take the tube would have to be about 5 ft. long and about 2½ ft. in diameter. Such a container could not have been manipulated into the positions necessary for getting the required pictures, would not have made it possible to get the tube close enough to the work for penetration through the three or more inches of metal in many of the areas tested, and could not have been introduced between the inlet and outlet vents to get the exposure required in that position. This is a characteristic example of materials which come up for test in our laboratory.

It is believed that the lead-lined cylinder described by Mr. St. John could not be mounted so as to provide sufficient flexibility for manipulating in much of the work that is apt to come up.

REPORT OF COMMITTEE E-6

ON

PAPERS AND PUBLICATIONS

During the year, the Committee on Papers and Publications has held one meeting, in February, 1926, at which the general arrangements for the program of the annual meeting were discussed and all offers of papers passed upon for acceptance in accordance with the rules. Since that meeting the Advisory Committee has acted for the committee on all matters relating to the program.

The budget for 1926 publications, while somewhat larger than that for 1925, nevertheless made it necessary for considerable curtailment of the volume of technical papers that could be accepted for publication in the Proceedings. The committee established the policy of accepting the maximum number of papers, asking the authors to condense them as much as possible, so that the whole field of activities of the Society might be fairly well covered. This year the volume of technical papers offered for presentation totaled slightly over 750 pages. It was necessary to reject certain offers and to decline a number of suggestions. The endeavor was then made to bring the papers that were accepted within the scope of 400 pages, which in many cases meant quite drastic reduction in individual papers. In this the committee has received the hearty cooperation of the various authors, but it was not found possible to keep the papers entirely within this limitation without very seriously detracting from the value of a number of papers on important subjects. The authors in those cases met the wishes of the committee in every reasonable way, and the committee feels that the 37 technical papers on the program, which it is estimated will occupy slightly under 500 pages, have been edited as well as possible with respect to space requirements.

It is worthy of note in passing that aside from a few important subjects which the committee decided should appear on the program and for which papers were solicited, the papers on the program represent offers by members in response to the usual invitation and are indicative of the considerable amount of investigation and study of materials resulting in technical data worthy of publication by the Society.

It is evident that the Society's business as represented by committee reports, and especially as relates to new and revised standards, must be provided for in the publication program. In this respect the volume of the 36 committee reports that are on the program has greatly exceeded the expectations, so much so that the size of the Proceedings upon which the year's budget was based will be considerably exceeded. It is estimated that the reports will occupy about 850 pages.

The conditions as to preprinting of these reports and papers has proved to be a difficult one. Under our rules and for obvious reasons the committee is obligated to preprint committee reports in so far as possible. Therefore 32 of the 36 reports have been preprinted, comprising 748 pages; the remaining four reports were not received in time for preprinting. Moreover, seven of the 32 preprinted reports have not been printed in their entirety, in most cases for the reason that the portions of the report omitted were received too late to make preprinting possible. The number of pages of reports preprinted has so greatly exceeded the expectations, as based on the experience of 1925, that it was not found possible to preprint as many of the technical papers as desired. However, a number of the technical papers were received too late to make preprinting possible, the net result being that of the 38 papers, including the Presidential Address, only 17 have been preprinted, with a total of 258 pages. This brings the total volume of reports and papers preprinted up to 1006 pages, which is about 100 pages over the estimate upon which the budget for the year was based.

It is interesting to compare the volume of reports and papers for this meeting with those for the two preceding meetings. This comparison is given below:

	1924	1925	1926
REPORTS:			
Total Number	41	35	36
Number of Preprints	33	33	32
Pages Preprinted	759	545	748
PAPERS:			
Total Number	45	26	38
Number of Preprints	30	20	17
Pages Preprinted	489	216	258
TOTAL REPORTS AND PAPERS:			
Total Number	86	61	77
Number of Preprints	63	53	49
Pages Preprinted	1248	761	1006

It will be remembered that 1924 was the largest publication year in the history of the Society, not only because of the large volume of committee reports, but more especially because of the big volume of technical papers, including two large symposiums. It is interesting to note that the volume of reports for this year will be practically the same as in 1924 but that the volume of papers is considerably less, although greater than in 1925.

The arrangement of the program this year follows in general the plan inaugurated two years ago which has proved to be quite successful. Also the details of presentation of reports and papers, particularly the matter of time schedule to be observed so far as possible by the presiding officer of each session, which was inaugurated for the first time last year, is being followed again this year.

During the year, the committee has considered several questions of policy having to do with the publication of the Proceedings, the Book of A.S.T.M. Standards and the Book of A.S.T.M. Tentative Standards, and upon the request of the Executive Committee has presented certain recommendations in these matters.

Work is now under way in the office of the Secretary-Treasurer for the publication of the collective index to the Proceedings for the years 1921 to 1925, inclusive, in accordance with the policy that has been adopted of issuing such an index at five-year intervals.

The committee has considered a recommendation of Committee E-4 on Metallography that glazed paper should be used for reproduction of photomicrographs in the Proceedings. The committee does not feel that we are justified in going to the greatly increased expense of using glazed paper in the Proceedings, but it has in mind that it may be justified in using glazed paper inserts for the reproduction of photomicrographs of especial importance. The committee realizes that the use of a finer screen with a more highly coated paper will result in better reproductions of photomicrographs; but the present reproduction of photomicrographs is on the whole very good and additional expense is warranted only in cases of particular importance.

The committee has determined to include a suitable note on the standards of the Society indicating the committee of the Society that is responsible for the standard.

The committee believes that more extensive use of the seal of the Society in connection with its publications is justified and has voted that the seal should be used on all standards and tentative standards in the bound publications (the seal has been used on the separate reprints for a number of years) and on all work that the Society sponsors, wherever this can be done in a dignified way. The seal was used on the preprints this year for the first time.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-8

ON

NOMENCLATURE AND DEFINITIONS

The past year in Committee E-8 has been marked by extreme activity on the part of its sub-committees. Much of the committee's work in the past, having to do with the correlation of definitions of terms as prepared by, or of interest to, a number of standing committees, has been carried on by sub-committees. This year possibly the major portion of the work has been carried out in this way. As a result, definitions are presented, either as information or for publication as tentative, by the Sub-Committees on Moisture and Ash, on Sand and Aggregate, on Concrete, on Cementitious Materials, on Sieve and Screen, and on Specific Gravity. The recommendations of these several sub-committees appear in this report where the activities of the sub-committees are discussed.

The sub-committee organization of Committee E-8 at present is as follows:

On Specific Gravity (F. M. Farmer, chairman).

On Definitions of Terms Relating to Cementitious Materials (L. I. Neale, chairman).

On Definitions of the Terms Sand and Aggregate (L. R. Ferguson, chairman).

On Definitions of the Terms Sieve and Screen (L. R. Ferguson, chairman).

On Definitions of Loam, Silt, Gravel and Related Terms (L. R. Ferguson, chairman).

On Definitions of Moisture, Ash, Volatile Matter and Fixed Carbon (H. C. Porter, chairman).

On Concrete (L. R. Ferguson, chairman).

This includes one new Sub-Committee on Concrete, under the chairmanship of L. R. Ferguson, the complete personnel of which is as follows:

C-9 L. R. Ferguson (*chairman*)
C-1 Ernest Ashton
C-3 D. K. Boyd
C-4 J. R. McClintock
C-6 P. H. Bates
C-11 L. I. Neale
D-4 Prévost Hubbard
D-8 C. N. Forrest

In addition to these, there is the special editorial committee of the Advisory Committee, which carries out much of the preliminary editorial review of the various definitions presented and reports direct to the Advisory Committee. Its recommendations are passed upon by the Advisory Committee and, if approved, are referred to the standing committee in question.

The work of Committee E-8, as well as that of its sub-committees, is handled so far as possible by correspondence. Following the precedent of the past few years, only one meeting of the general committee has been held during the year, this meeting having been held on May 5, 1926, to act upon the approval of definitions going to standard and to take action upon the recommendations of the several sub-committees. The Advisory Committee held two meetings, one in December, 1925, and the other in May, 1926.

One encouraging feature in connection with the work of Committee E-8 is the apparent tendency on the part of standing committees to look to Committee E-8 for suggestions in the preparation of definitions. The standing committees are no longer content to prepare definitions and submit them for publication as tentative, to have them follow the usual procedure of approval and adoption, but in many instances refer the definitions to Committee E-8 while these are still in a formative or sub-tentative stage, requesting Committee E-8 to comment upon the form of the definitions and the conciseness and clarity of wording. In this way, many definitions have been referred to the committee during the past year and as a result the definitions are being submitted as tentative in a more nearly final form.

In all, Committee E-8 has now approved 94 definitions as standard. It still has 107 tentative definitions before it for review and in addition there are 258 standard definitions that have not yet received the review and approval of the committee. Before discussing in detail the definitions submitted as tentative and those being recommended for adoption, the work of the several sub-committees is presented.

SUB-COMMITTEE ON SPECIFIC GRAVITY

The Sub-Committee on Specific Gravity, under the chairmanship of Mr. F. M. Farmer, presented in 1925 for publication as tentative, definitions for the terms "absolute specific gravity (of solids and liquids)," "specific gravity (of solids and liquids)," "apparent specific gravity (of solids)," and "bulk specific gravity (of solids)." These definitions were reviewed during the year by the Advisory Committee.

Some rearrangements, particularly in reference to the notes to the definitions, seemed desirable. Recommendations concerning such rearrangements were referred to the Sub-Committee on Specific Gravity, and accordingly the following revisions are recommended in the Tentative Definitions of Terms Relating to Specific Gravity (E 12 – 25 T)[1]:

In each of the definitions change the form of expression "when the temperature of the material and that of the water" to "when the temperatures of the material and of the water."

The first note under definition No. 4 applies to definition No. 3 as well. The present note under No. 3 should accordingly be designated "Note 1" and the first note under definition No. 4 should be made "Note 2" under definition No. 3.

Add a new note under definition No. 4 to read "See Note 2 under 'Apparent Specific Gravity.'" The second note under definition No. 4 applies to each of the definitions. It should accordingly be placed after each of the definitions, the wording to be changed to read as follows:

> "In the interest of standardization and simplification, the first form of statement of specific gravity (*a*) should be employed wherever practicable.

It is recommended that these revisions be accepted and that the definitions as revised be continued as tentative.

SUB-COMMITTEE ON SIEVE AND SCREEN

The Sub-Committee on Definitions of the Terms Sieve and Screen, under the chairmanship of L. R. Ferguson, presented as information in 1924 a definition for the term "screen (sieve)." A number of comments were received on this definition, and in the light of them the sub-committee revised its definition and submitted it in 1925 for publication as tentative. It appears as a tentative definition under the serial designation: E 13 – 25 T[2] and reads as follows:

> "*Screen* (*Sieve*).—A plate or sheet or a woven cloth, with regularly spaced apertures of uniform size, mounted on a suitable frame or holder, for use in separating materials according to size.
>
> "NOTE.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties, should be taken care of in specifications."

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 887 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 806.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 889 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 808.

Objections have been raised to it, including the following:

1. The terms "sieve" and "screen" should not be synonymous; each term should have a distinct meaning, which if generally adopted, would serve to economize the use of descriptive words.
2. A distinction should be made that a sieve is a laboratory apparatus and a screen an apparatus for use in the field (commercial use).
3. A sieve should indicate a device with rectangular openings; a screen a device with round openings.
4. A sieve should be one with openings of less than $\frac{1}{4}$ in., a screen one with openings $\frac{1}{4}$ in. or over in size.
5. A sieve should be a device consisting of woven wire; a screen a perforated plate.

These objections were given due consideration by the sub-committee. At the time the present definition was formulated, it was recognized that there was considerable confusion in the indescriminate use of the term "sieve" and "screen," one instance being the expression "U. S. Bureau of Standards Standard Screen Scale Sieve." It was with this in mind that a definition had been prepared which considered the terms "sieve" and "screen" as synonymous. On the other hand, it would appear that in at least one industry, namely, road construction, a distinction is made between "sieve" and "screen," as is evidenced by the present definition for these terms appearing in the Standard Definitions of Terms Relating to Materials for Roads and Pavements (D 8 - 18). The sub-committee now makes the recommendation that this distinction be recognized by a note to the present definition for "screen (sieve)," the note to read as follows:

"NOTE 2.—In mechanical analysis testing work the term 'sieve' when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are rectangular. The term 'screen' when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are circular."

SUB-COMMITTEE ON SAND AND AGGREGATE

The Sub-Committee on Sand and Aggregate, under the chairmanship of L. R. Ferguson, has, for the present, but two definitions before it, namely, for the terms "sand" and "aggregate." A definition for the former was presented for publication as tentative in 1924, after having been published as information during the previous year.

The definition as it at present appears in the Proceedings of the Society under the Serial Designation: C 58 – 25 T[1] is as follows:

> "*Sand.*—The fine granular material resulting from the natural disintegration or the crushing of rock or slag.
>
> "NOTE.—When used without a qualifying adjective it is generally understood to mean a product of the natural disintegration of siliceous or calcareous rock. The size of particle and other physical characteristics should be taken care of in specifications and therefore no limits are mentioned in the definition."

The sub-committee had in mind recommending the definition for advancement to standard and so advised the standing committees of the Society. A number of criticisms were subsequently received, which, briefly summarized, are the following:

1. "Sand" should only include the product of the natural disintegration of rock.
2. "Sand" should be limited to only hard, durable materials. (Some have even suggested that the definition be limited to siliceous or possibly siliceous and calcareous materials.)
3. A size limitation of $\frac{1}{4}$ in. should be given.
4. "Sand" should not include "crushed slag."

While several of these objections were held to be scarcely pertinent, in that the definition was not intended to be a specification for sand suitable for a specific purpose, one or two of the objections seemed to have real merit. Probably the most valid objections were those to the effect that "sand" should not include stone screenings, nor should it include slag, even though terms such as slag-sand may be in general use and accordingly might imply the desirability of a generic definition for sand. The sub-committee accordingly presents the following definition to replace the present Tentative Definition for the Term Sand (C 58 – 25 T):[1]

> "*Sand.*—The fine granular material (usually less than $\frac{1}{4}$ in. in diameter) resulting from the natural disintegration of rock, or from the crushing of friable sandstone rocks.
>
> "NOTE.—When used without a qualifying adjective, 'sand' is generally understood to mean the product of the natural disintegration of siliceous or calcareous rock. Sand should be distinguished from screenings, gravel, etc. The size of particle and other physical characteristics should be taken care of in specifications. The fine material resulting from the crushing of blast-furnace slag is known as 'slag sand.'"

It is recommended that the new definition be approved for publication as tentative.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 635 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 257.

In the 1925 Report of Committee E-8 a definition was presented as information for the term "aggregate" reading as follows:

"*Aggregate.*—Inert mineral material which when bound together into an agglomerated mass by a matrix forms concrete, mastic, mortar, plaster, etc."

It was pointed out that this definition was faulty in that "aggregate" was not necessarily mineral material. On the other hand, some qualification needed to be given so as to exclude extraneous substances from falling under the definition for "aggregate." To provide for this the introductory word "designated" is employed in the following definition, which is recommended by Committee E-8 for publication as tentative:

"*Aggregate.*—Designated inert material, which when bound together into an agglomerated mass by a matrix forms concrete, mastic, mortar, plaster, etc."

SUB-COMMITTEE ON CONCRETE

The newly organized Sub-Committee on Concrete, under the chairmanship of L. R. Ferguson, has given considerable thought to the preparation of a definition for the term "concrete." It felt that since the term is applied to a number of materials a general definition applicable to all these materials would be the most desirable. On the other hand it recognized that generally speaking, portland-cement concrete was implied wherever the term concrete was employed without a qualifying adjective, as for instance, in the expression, "a reinforced-concrete building." In order to have the benefit of the comments of all those interested it presents for publication as information the following definition. Criticisms and suggestions are solicited.

"*Concrete.*—A combination of aggregate or aggregates with a binding medium which, after mixing, solidifies into a conglomerate mass.

"NOTE.—In the present state of the art, the term 'concrete,' when used without a qualifying adjective, is understood to mean portland-cement concrete."

SUB-COMMITTEE ON CEMENTITIOUS MATERIALS

The Sub-Committee on Cementitious Materials, under the chairmanship of L. I. Neale, was organized to review a series of definitions prepared by Committee C-11 on Gypsum, but yet which seemed of general applicability. The terms in question are the following:

Accelerator
Binder
Cement
Lath
Mortar
Plaster
Retarder
Stucco
Wood Fiber

These definitions have been given extended consideration in the sub-committee. Suggested rewordings were, in turn, given consideration by the Advisory Committee, and as the result of discussions that transpired between the sub-committee and the Advisory Committee, suggested definitions for the nine terms were presented by the sub-committee. These are given in the report of the sub-committee, appended hereto. These definitions are submitted as information.

SUB-COMMITTEE ON MOISTURE, ASH, VOLATILE MATTER AND FIXED CARBON

The Sub-Committee on Moisture, Ash, Volatile Matter and Fixed Carbon, under the chairmanship of H. C. Porter, was suitably enlarged as to personnel in order that it might satisfactorily develop general definitions for the terms under its jurisdiction. This it has been successful in accomplishing so far as the definitions for "moisture," "ash" and "volatile matter" are concerned. The sub-committee, however, believes that it is not feasible to prepare a general definition for the term "fixed carbon," but a definition has been developed as applying to coal, coke and bituminous materials. It is felt that these are the only materials that warrant a definition for "fixed carbon" at the present time, so far as the work of the standing committees of the Society is concerned. The four definitions which are submitted herewith as information and upon which comments are solicited, are as follows:

Moisture.—Essentially water in a material, quantitatively determined, by definite prescribed methods which may vary according to the nature of the material.

NOTE.—Such methods may not determine all of the water present.

Ash.—Inorganic residue remaining after ignition of combustible substances determined by definite prescribed methods.

NOTE.—The ash as thus defined may not be identical in composition or quantity with the inorganic substances present in the material before ignition.

Volatile Matter.—Those products, exclusive of moisture, given off by a material as gas or vapor, as determined by definite prescribed methods which may vary according to the nature of the material.

Fixed Carbon.—In the case of coal, coke and bituminous materials, the solid residue other than ash, obtained by destructive distillation, as determined by definite prescribed methods.

NOTE.—Besides carbon, it may contain appreciable quantities of sulfur, hydrogen, nitrogen and oxygen.

DEFINITIONS OF TERMS APPROVED BY COMMITTEE E-8

As a matter of record, the complete list of the 94 terms approved by Committee E-8 is included as given below:

Aging Coefficient
Alloy
Alpha Brass
A.S.T.M. Paraffin Wax Melting Point
A.S.T.M. Petroleum Melting Point
Bad Start-Up
Baggy Fabrics
Beta Brass
Book Tile
Calcined Gypsum
Cells
Chafed Cord
Clay
Clay Separate
Coercive Force
Core Loss
Corkscrew Twist
Correction
Crushed Gypsum
Defective Splice
Drying Oil
Enamel
End-Construction Tile
Equi-axed Grain
Error
Etching Reagent
Filler
Fire Clay
Float
Foundation Tile
Furring Tile
Grain
Grain Size
Gypsum
Hollow Floor Tile
Hollow Tile
Hollow Tile Fireproofing
Imperfect Selvage
Irregular Pick
Kink
Knot
Knot of Finished Cord
Lake
Length
Load-Bearing Wall Tile
Loading Range
Macrograph
Magnetic Permeability
Magnification
Metal
Micrograph
Micpick or Broken Pick
Missing Cord
Missing Warm Thread
Non-Drying Oil
Normal Induction
Organic Acetone Extract
Partition Tile
Percentage of Error
Porous Hollow Tile
Pucker
Reed Mark
Residual Induction
Salt-Glazed Tile
Saponifiable Acetone Extract
Scoring
Semi-Drying Oil
Sewed Thread
Shale
Shell
Side-Construction Tile
Size
Slack and Tight Warp or Filling Threads
Slack and Tight Cords
Slug
Smash
Split Tile
Split or Chafed Yarn
Standard Core Loss
Surface Clay
Testing Machine
Thick and Thin Places (Major)
Thick and Thin Places (Minor)
Thickness
Thin Places (Major)
Thin Places (Minor)
Tolerance
Toner
Total Waxy Hydrocarbons
Unsaponifiable Resins
Varnish
Webs
Width
Wrong Draw

In addition to the 67 terms mentioned in the report of the committee for 1925, 27 additional terms have been added as adopted at the 1925 annual meeting.

TENTATIVE DEFINITIONS BEFORE COMMITTEE E-8

As mentioned, at the 1925 annual meeting of the Society, 27 tentative definitions of terms were adopted as standard. Twelve new tentative definitions were submitted as follows:

Absolute Specific Gravity (of solids and liquids)
Alkali Neutralization Number
Annealing
Apparent Specific Gravity (of solids)
Available Lime
Bulk Specific Gravity (of solids)
Mineral Acid Neutralization Number
Neutralization Number
Normalizing
Sand
Screen (Sieve)
Specific Gravity (of solids and liquids)

This leaves 107 tentative definitions now before Committee E-8 for consideration. These are grouped below according to subject matter, and the present status of these definitions is indicated.

Terms Relating to Coke (D 121).—The 15 terms defined by Committee D-5 on Coal and Coke are as follows:

Coke
Beehive Coke
By-Product Coke
Gas House Coke
Coke Breeze
Domestic Coke
Foundry Coke from Beehive Ovens
Foundry Coke from By-Product Ovens
Furnace Coke from Beehive Ovens
Furnace Coke from By-Product Ovens
Dry Coke
Moisture
Ash
Volatile Matter
Fixed Carbon

The definitions of the terms "moisture," "ash," "volatile matter" and "fixed carbon" are reported upon in connection with the activities of the Sub-Committee on Moisture, Ash, etc. The definitions of the remaining 11 terms were reviewed by the Advisory Committee and certain rewording suggested to Committee D-5. The committee has received other criticisms concerning the substance of the definitions and accordingly the definitions have been withdrawn and new definitions as applying to both coal and coke are being submitted at this annual meeting.

Terms Relating to Coal (D 142).—The 6 terms presented by Committee D-5 on Coal and Coke are as follows:

Moisture
Ash
Volatile Matter
Fixed Carbon
Proximate Analysis
Ultimate Analysis

The terms "moisture," "ash," "volatile matter," and "fixed carbon," as in the case of these terms as defined as relating to coke, are covered under a special sub-committee. The definitions relating to coal are being combined with those relating to coke in a new set of definitions being submitted this year by Committee D-5. These definitions include revisions of the definitions for "proximate analysis" and "ultimate analysis," bringing these definitions in agreement with the recommendations of the Advisory Committee.

Terms Relating to Gypsum (C 11, C 22, C 23, C 36, C 37, C 52).—The 20 terms appearing in these standards, as defined by Committee C-11 on Gypsum, are as follows:

Accelerator
Aggregate
Binder
Calcined Gypsum
Cement
Consistency
Crushed Gypsum
Gypsum
Gypsum Partition Tile or Block
Gypsum Plastering Sand
Gypsum Plaster Board
Gypsum Wall Board
Lath
Mortar
Plaster
Plasticity
Retarder
Sized Gypsum
Stucco
Wood Fiber

With the exception of the definition for "gypsum partition tile or block" these definitions all appear in the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11). Committee C-11 is recommending the advancement to standard of these tentative definitions. Nine of them have been under consideration by the Sub-Committee on Cementitious Materials and are being reported upon as given in the appended report of the sub-committee. The remaining definitions have received the review of the Advisory Committee, and Committee E-8 is prepared to approve the advancement to standard of the definitions of the following terms in addition of the 9 terms covered by the Sub-Committee on Cementitious Materials:

Accelerator
Binder
Cement
Calcined Gypsum
Crushed Gypsum
Gypsum
Gypsum Plastering Sand
Lath
Mortar
Plaster
Retarder
Sized Gypsum
Stucco
Wood Fiber

Approval of the definitions for the terms "gypsum plaster board" and "gypsum wall board" is withheld, since agreement on these two definitions has not yet been secured between Committee C-11 and Committee E-8. The definition for "aggregate" falls under the jurisdiction of the Sub-Committee on Sand and Aggregate and a final report of this sub-committee has not yet been presented. The definitions for the terms "consistency" and "plasticity" await the findings of a Sub-Committee, of Committee E-1 on Methods of Testing, on Consistency, Plasticity, etc.

The definitions in question were referred to letter ballot in Committee E-8 with the following results: Advisory Committee, 7 affirmative, 0 negative, 0 not voting, total 7. Standing Committees, 16 affirmative, 2 negative, 21 not voting, total 39.

Terms Relating to Lime (C 51, C 25).—The 7 terms defined by Committee C-7 on Lime are as follows:

Quicklime
Hydrated Lime
In Bulk
Lump Lime
Lump Lime Screened
Pulverized Lime
Available Lime

Committee E-8 gave these definitions an editorial review, and since Committee C-7 appeared to be the only standing committee interested, the definitions were referred to that committee only, with a number of suggestions for rewording. Committee E-8 questioned the utility and the need for the definition of the term "in bulk" and referred the matter to Committee C-7 for advice.

The remaining definitions have been revised and are in substantially the form recommended by Committee E-8. The definitions, however, are not being recommended for advancement to standard this year, and accordingly no letter ballot has been conducted in Committee E-8 this year.

Terms Relating to Waterproofing Materials (D 147).—The 3 definitions submitted by Committee D-8 on Waterproofing Materials are as follows:

Bituminous Grouts
Bituminous Mastics
Mastic Cake

These terms have since been changed to "bituminous grout," "asphalt mastic" and "asphalt mastic cake," respectively. Committee E-8 and Committee D-8 are in agreement as to their wording, but since the definitions are not being recommended for advancement to standard this year, they have not been referred to the membership of Committee E-8 for approval.

Terms Relating to Textiles.—A number of terms relating to textiles were approved at the 1925 annual meeting for advancement to standard. There still remain, however, 19 tentative definitions appearing in the Tentative Definitions of Terms Relating to Textile Materials (D 123) as follows:

Mechanical Fabric
Tire Builder Fabric
Tire Cord Fabric
Hose Duck
Rubber Belt Duck
Balata Belt Duck
Oil Belt Duck
Numbered Duck
Army Duck
Single Filled or Flat Duck
Enameling Duck
Twill
Drills
Alberts
Jeans
Serge
Clay
Crimp
Off-Square

In addition, a tentative definition for "direction of twist" appears in the Tentative Specifications for Tolerance and Test Methods for Cotton Yarns, Single and Plied (D 180) and in the Tentative Specifications for Tolerances and Test Methods for Cotton Sewing Threads (D 204). Committee D-13 is this year recommending that all the definitions of terms relating to textile materials be grouped in one document. To accomplish this, the definitions appearing in those specifications that are now standard are being recommended for inclusion in the Tentative Definitions of Terms Relating to Textile Materials (D 123), together with such other definitions as may now be included in the tentative specifications. In addition, the committee is recommending a number of new tentative definitions of terms.

Terms Relating to Paint.—Committee D-1 on Preservative Coatings still has before it 3 tentative definitions, namely, definitions for the terms "toughness," "elasticity of paint and varnish films" and "screen (sieve)." No action in regard to these definitions is being recommended this year by Committee D-1.

Terms Relating to Methods of Testing.—Committee E-1 on Methods of Testing submitted in 1924 a definition for the term "compressive strength" in its Tentative Methods of Compression Testing of Metallic Materials (E 9). This definition received the review of Committee E-8 and a revision was recommended by Committee E-1 in 1925, bringing the definition in line with the recommendations of Committee E-8.

In addition, definitions for the following 8 terms appear in the Tentative Definitions of Terms Relating to Methods of Testing (E 6), Tentative Methods of Compression Testing of Metallic Materials (E 9), and the Tentative Methods of Tension Testing of Metallic Materials (E 8):

Stress
Strain
Stress-Strain Diagram
Elastic Limit
Yield Point
Tensile Strength
Compressive Strength
Modulus of Elasticity

These have all been brought in line with the recommendations of the Advisory Committee but no action is being taken this year by Committee E-1 toward advancing the definitions to standard.

Miscellaneous Terms.—There are 3 terms classed as miscellaneous:

Ductility (D 113)
Specific Gravity (D 70, D 71)
Concrete Brick (C 55)

The definition of "ductility" (as given by Committee D-4 on Road and Paving Materials) as applying to the ductility of asphalt cement was referred back to Committee D-4, since it was felt by Committee E-8 that the definition as worded could scarcely be considered as definition of ductility but rather a description of how that property is determined. Committee D-4 is contemplating revising the methods in which this definition appears. The definition of "ductility" will come up for consideration in conjunction with this general revision. Committee D-4, responsible for the definition of "specific gravity" appearing in Methods D 70 and D 71, is considering the revision of these two methods and will bring the definitions in line with the recommendations of the Sub-Committee, of Committee E-8, on Specific Gravity, under the chairmanship of F. M. Farmer. The definition for "concrete brick" was presented in 1924 by Committee C-3 on Brick, and is receiving the consideration of Committee E-8.

Definitions Submitted as Information

In addition to the several definitions submitted as information with this report, some of the standing committees of the Society have submitted with their reports definitions put forth to solicit comments and suggestions or have submitted these definitions direct to Committee E-8 for comment:

Definition of the Term Slate.—Committee D-16 on Slate submitted to Committee E-8 a definition for the term "slate." Committee E-8 made several suggestions in regard to the form of the definition and Committee D-16 is now submitting this definition in its revised form for publication as tentative.

Definition of Corrosion.—A definition of the term "corrosion" was included in the 1925 report of Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys. This definition was reviewed by the Advisory Committee of Committee E-8 and comments submitted to Committee B-3.

Terms Relating to Petroleum Products.—Committee D-2 has followed the practice of preparing definitions and circularizing these before submitting the definitions as tentative. In the committee's 1924 report, a number of definitions were included, and in its report for 1925 revisions of a number of these definitions were given, as well as definitions of additional terms, the complete list being as follows:

Crude Petroleum (Crude Oil, Petroleum, Crude)
Topped Crude
Weathered Crude
Benzine
Petroleum Naphtha
Gasoline
Petroleum Spirits
Kerosine
Mineral Seal Oil
Gas Oil
Fuel Oil
Tar, Pitch
Grease
Oil-Shale
Shale Oil
End Point

Since then, some new definitions have been prepared by the committee.

Terms Relating to Timber.—An extensive set of definitions of terms relating to timber is being prepared by Committee D-7 on Timber in cooperation with the Central Committee on Lumber Standards. A number of definitions prepared by Committee D-7 were referred to Committee E-8 during the year which included definitions for the following terms:

Defect
Blemish
Bark Pocket
Check
Surface Check
End Check
Through Check
Heart Check
Shake
Honeycombing
Collapse
Cross Break
Cross-Grained Wood
Spiral-Grained Wood
Diagonal-Grained Wood
Wavy-Grained Wood
Dip-Grained Wood
Curly-Grained Wood
Interlocked-Grained Wood
Decay
Incipient Decay
Firm Red Heart
Water-Soak (or Stain)
Advanced (or Typical) Decay
Knot
Pith
Wane
Annual Ring
Springwood
Summerwood
Sapwood
Heartwood

These definitions were reviewed by the Advisory Committee and they have been brought substantially in line with the Advisory Committee's recommendations. No action is being recommended on the definitions at the present time.

Definition of Shearing Strength.—A definition for the term "shearing strength" was included in the Proposed Methods of Torsion Testing of Metallic Materials submitted as information by Committee E-1 on Methods of Testing. This definition has been brought in line with other definitions relating to methods of testing.

Definitions of Terms Relating to Heat Treatment.—The American Society for Steel Treating prepared a series of definitions of terms relating to heat treatment, which was referred to a number of organizations for criticism, including the American Society for Testing Materials. The Executive Committee referred these definitions to Committee A-4 on Heat Treatment of Iron and Steel. Committee A-4 in submitting a number of comments for transmission to the A.S.S.T. recommended that a joint committee of nine be appointed to consist of three representatives of each of the following organizations: American Society for Steel Treating, Society of Automotive Engineers, American Society for Testing Materials. This joint committee is now submitting a report which will receive the consideration of Committee A-4 and of Committee E-8 during the coming year.

The recommendations appearing in this report have been submitted to letter ballot of the committee with the following results:

Items	Affirmative	Negative	Not Voting
I. REVISIONS OF TENTATIVE DEFINITIONS			
1. Tentative Definitions of Terms Relating to Specific Gravity (E 12 - 25 T)	25	1	20
2. Tentative Definition of the Term Sand (C 58 - 25 T)	20	2	24
3. Tentative Definition of the Term Screen (Sieve) (E 13 - 25 T)	22	2	22
II. DEFINITION SUBMITTED AS TENTATIVE			
4. Definition of the Term Aggregate	21	0	25
III. DEFINITIONS SUBMITTED FOR PUBLICATION AS INFORMATION			
5. Definition of the Term Concrete	18	3	25
6. Definitions of the Terms Moisture, Ash, Volatile Matter and Fixed Carbon	22	0	24
7. Definitions of Terms Relating to Cementitious Materials	16	0	30

This report has been submitted to letter ballot of the committee, which consists of 46 members, with the following results: Advisory Committee, 7 affirmative, 0 negative, 0 not voting, total 7. Standing Committees, 31 affirmative, 0 negative, 8 not voting, total 39.

Respectfully submitted on behalf of the committee,

CLOYD M. CHAPMAN,
Chairman.

R. E. HESS,
Ex-Officio Secretary.

EDITORIAL NOTE

The proposed revisions of the Tentative Definitions of Terms Relating to Specific Gravity; of the Tentative Definition of the Term Sand; and of the Term Screen (Sieve) were accepted. The tentative definitions as revised appear on pages 1089, 787 and 1091, respectively.

The proposed Tentative Definition of the Term Aggregate was accepted for publication as tentative and appears on page 787.

REPORT OF SUB-COMMITTEE ON CEMENTITIOUS MATERIALS

The sub-committee offers the following definitions of the terms before it:

Accelerator.—In the case of stucco, plaster, mortar, concrete, etc., a substance which will hasten the set.

Binder.—In the case of plaster and stucco, etc., a fibrous material, which will increase their cohesiveness, while they are in a plastic state.

Cement.—A material or a mixture of materials (without aggregate) which, when in a plastic state, possesses adhesive and cohesive properties, and which will harden in place.

Note.—The word "cement" is used without regard to the composition of the material.

Mortar.—A material used in a plastic state, which can be troweled, and becomes hard in place, to bond units of masonry structures.

Note.—The word "mortar" is used without regard to the composition of the material, and is defined only with reference to its use as a bonding material as contrasted with the words "stucco" and "plaster."

Plaster.—A material used in a plastic state, which can be troweled, to form a hard covering for the interior surfaces, walls and ceilings, etc., in any building or structure.

Note 1.—The word "plaster" is used without regard to the composition of the material, and is defined only with reference to its use and location of use as contrasted with the words "stucco" and "mortar."

Note 2.—This does not include decorative media ordinarily applied with a brush.

Retarder.—In the case of stucco, plaster, mortar, concrete, etc., a substance which will retard set.

Stucco.—A material used in a plastic state, which can be troweled, to form a hard covering for the exterior walls or other exterior surfaces of any building or structure.

Note.—The word "stucco" is used without regard to the composition of the material, and is defined only with reference to its use and location of use as contrasted with the words "plaster" and "mortar."

Wood Fiber.—A material produced by grinding or shredding wood.

Lath.—A material whose primary function is that of a base or background for the reception of plaster or stucco.

Note.—The word "lath" is used without regard to the composition of the material, and is defined only with reference to its use.

Respectfully submitted on behalf of the sub-committee,

L. I. Neale,
Chairman.

REPORT OF COMMITTEE E-9
ON
CORRELATION OF RESEARCH

The committee during the year has held two meetings, both in the Society rooms at Philadelphia, the first on October 14, 1925, and the second on April 12, 1926.

Broadly stated, it is the function of the committee to consider means by which the work of the Society in promoting knowledge of engineering materials may best be advanced, to encourage and stimulate investigations for this purpose under the auspices of the Society, and to seek to bring about studies of those properties of materials concerning which information is needed. The work of the committee during the past year has been carried on with these objectives very directly in view.

The committee has made it one of its principal duties to become as fully informed as possible of the investigations on properties of materials that are being carried on under the auspices of the Society, either by its own committees or jointly with other organizations. A year ago it reported the compilation, with the cooperation of the officers of the standing committees, of a "List of Current and Proposed Researches and Investigations by A.S.T.M. Committees" based upon an examination of standing committee reports from 1919 to 1924, and including all investigations designed primarily to promote knowledge of engineering materials. Since then, this information has been brought abreast of the reports of the committees for 1925 and has been placed in card index form, classified according to subject, with complete cross-references, and according to methods of administration of the particular research project, that is (1) projects administered by A.S.T.M. standing committees, (2) projects administered by A.S.T.M. research committees, (3) projects administered by joint committees sponsored by the Society, and (4) projects sponsored by other organizations upon whose committees the Society is represented. This index is on file in the Secretary's office and has been invaluable in outlining the activities of the committee.

There is appended to this report a list of the titles of the various research projects classified as indicated above, from which the volume and extent of the research work now being done under the auspices of the Society is apparent. With one or two exceptions the list does not include new researches initiated since the 1925 annual meeting. Information regarding the status of the projects is maintained by the committee and will gladly be furnished to any committee or member of the Society upon request. Most of these projects are active.

RESEARCH COMMITTEES OF THE SOCIETY

Research Committee on Effect of Tin and Arsenic on High-Speed Tool Steels.—In its report last year Committee E-9 stated that it had recommended the formation of a small research committee to study the effect of tin and arsenic on high-speed tool steels and that this recommendation had been approved by the Executive Committee. The research committee was organized at Cleveland in October, 1925, with the following personnel:

N. B. Hoffman (chairman), Metallurgist, Colonial Steel Co.
J. V. Emmons, Metallurgist, Cleveland Twist Drill Co.
G. E. F. Lundell, Chemist, U. S. Bureau of Standards.
J. H. McCadie, Metallurgist, National Twist Drill and Tool Co.
A. E. White, Director of Engineering Research, University of Michigan.

The committee is making satisfactory progress in its studies of this problem. Upon the recommendation of Committee A-1 on Steel, the suggestion has been made to the research committee that it include in its investigations a study of the effect of antimony upon high-speed tool steels. This suggestion is to be considered at the next meeting of the research committee.

Joint Research Committee on Effect of Temperature on the Properties of Metals.—This research committee, functioning under the joint auspices of this Society and the American Society of Mechanical Engineers, has been making satisfactory progress. The committee has instituted a series of short-time high-temperature tension tests on four types of steel, at six stated temperatures. The tests are being made by about twelve selected laboratories prepared to make such tests with their equipment according to carefully detailed test methods that have been specified by the committee. The tests are designed primarily to determine the tensile properties of these metals at elevated temperatures and to study the methods of testing. Plans are being formulated for work on other physical properties at high temperatures. The committee has met with a very gratifying response in its request for cooperation in carrying on the extended tests that will be involved in this research.

The work of this committee has grown to an extent that has suggested the desirability of its reorganization upon a somewhat more comprehensive basis than at present. The sponsors of the committee in cooperation with the committee itself are at work upon a proposed enlargement of the personnel and the organization of a small executive group within the enlarged committee for active administration of its work.

Research Committee on Yield Point of Structural Steel.—Perhaps the outstanding accomplishment of Committee E-9 this year has been the organization of a Research Committee on Yield Point of Structural Steel, as forecast in the annual report a year ago. Consultation with groups directly interested showed clearly the desirability of investigation of the general question of yield point of structural steel, and with the approval of the Executive Committee a research committee on this subject was organized in Chicago on March 12, 1926, under the chairmanship of M. O. Withey. This question is so intimately associated with questions of manufacture and of structural design that cooperation of certain other societies and associations was thought desirable and was secured. The personnel of the committee is now as follows:

	APPOINTED BY
M. O. Withey (chairman), Professor of Mechanics, University of Wisconsin	Am. Soc. Testing Mats.
T. R. Lawson, Professor of Rational and Technical Mechanics, Rensselaer Polytechnic Inst.	Am. Soc. Testing Mats.
F. E. Schmitt, Associate Editor, *Engineering News-Record*	Am. Soc. Testing Mats.
Clarence Hudson, Consulting Engineer	Am. Soc. Civil Engrs.
A. W. Carpenter, Assistant Valuation Engineer, New York Central Railroad	Am. Railway Eng. Assn.
John Brunner, Manager, Department of Metallurgy and Inspection, Illinois Steel Co.	Assn. Am. Steel Mfrs.
E. F. Kenney, Metallurgical Engineer, Bethlehem Steel Co.	Assn. Am. Steel Mfrs.
L. H. Miller, Chief Engineer, American Institute of Steel Construction	Am. Inst. Steel Constr.

In organizing this research committee, Committee E-9 indicated broadly the nature of the problem as the study of range and characteristics of yield point in specimens and members of structural steel, pointing out that the problem is one of great interest to at least three groups: the structural engineer, the steel manufacturer and the testing engineer. The research committee has prepared a tentative statement of the problem and already has under way a study of the effect of speed of testing machine on yield point. The committee seems to have made an excellent start on its work.

RESEARCH WORK IN STANDING COMMITTEES OF THE SOCIETY

Research work under the auspices of our standing committees is outlined in the appendix to this report previously discussed. Committee E-9 has kept rather directly in touch with certain of these investigations, notably those on wrought iron, under the auspices of Committee A-2, upon which it is expected that committee will report this year. The committee has also received progress reports upon the investigation on effect on properties of steel forgings of amount of reduction between ingot and bloom, under the auspices of Committee A-1; the study of the properties of babbitt metal, under the asupices of Committee B-2; and the design of concrete, under the auspices of Committee C-9.

CERTAIN IMPORTANT RESEARCH PROBLEMS

Corrosion-Resistant Alloys.—Committee E-9 has been studying the development, under the auspices of the Society, of research in the field of corrosion-resistant alloys. The 1924 Symposium on Corrosion-Resistant, Heat-Resistant and Electrical-Resistance Alloys[1] emphasized very clearly the importance of investigations in these three fields. The heat-resistant alloys will be studied by the above-mentioned Joint Committee on Effect of Temperature upon the Properties of Metals. The development of electrical-resistance alloys has progressed to the point where standardization of test methods and probably of the materials themselves is now possible, and this field has been assigned to the recently organized Committee B-4 on Metallic Materials for Electrical Heating. Standardization of corrosion-resistant alloys is neither possible nor advisable in the present state of development of these alloys, but investigation of their properties, particularly as concerns resistance to corrosion, is needed, in the opinion of all whom the committee has consulted.

Two committees of the Society are studying broadly the problem of corrosion, Committee A-5 on Corrosion of Iron and Steel working in the field of ferrous metals and Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys in the non-ferrous metals field. The corrosion-resistant alloys fall in both fields and therefore are of interest to both Committees A-5 and B-3. Committee E-9 is conferring with these two committees on this general subject, to see how research on corrosion-resistant alloys may best be developed by the Society.

Other Research Problems.—Committee E-9 has also given consideration to research problems in connection with the following subjects which have come to its attention from various sources:

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 24, Part II, p. 189 (1924).

Foreign inclusions in steel.
Gases in steel.
Relation between metals in cast test bars and in castings.
Light high-strength alloys.
Cast-iron pipe.
Effect of combined fatigue and corrosion.
Quality of steel as affecting column strength.
Cement.
A study of concrete failures.
The general subject of plasticity of materials.
Mineral aggregates.

In some cases these subjects will be brought to the attention of the standing committees or of research committees whose field of work includes a given problem or similar problems. In other cases, the subject has been taken up with the Committee on Papers and Publications with a view to the proper discussion of the matter at some later meeting of the Society. In still other cases other organizations seem to be doing work in this field whose development might well be awaited before taking further action.

Mr. Breyer, a member of the committee, has been at work during the year on the development of an outline of desired knowledge of materials and his classification scheme for information on materials in its present form has been referred to Committee E-1 on Methods of Testing with a request for consideration and comment.

Committee E-9 notes with satisfaction the establishment of the Charles B. Dudley Medal and the Edgar Marburg Lecture, two projects which were recommended by the committee in its 1925 report.

Committee E-9, while it has not yet had to face the problem of finances in any extensive research, endeavors to give financial problems in connection with research due consideration and to keep in touch with the committees more directly concerned with the financial interests of the Society.

Respectfully submitted on behalf of the committee,

H. F. MOORE,
Chairman.

C. L. WARWICK,
Secretary.

APPENDIX

LIST OF A.S.T.M. RESEARCH PROJECTS

There is given below a list of A.S.T.M. research projects under the following classifications:

1. Projects administered by A.S.T.M. standing committees;
2. Projects administered by A.S.T.M. research committees;
3. Projects administered by joint committees sponsored by the Society.

With the exception of the projects in charge of the two research committees of the Society, the list records projects as of the date of the annual meeting of the Society in 1925; that is, it does not include projects that may have been initiated by the standing committees since that meeting.

The projects are listed only by brief title and index classification. A statement of the scope of each project, the manner of its administration, and its present status is on file at the headquarters of the Society and information relating thereto will gladly be furnished to any committee or member of the Society upon request.

The standing committees of the Society whose names do not appear in the list fall in two classes: first, those whose activities have not involved any research in materials; and second, those that are devoting their major attention to methods of testing, in connection with which they are conducting many investigations (some of considerable magnitude) but which are not intended primarily to promote knowledge of the materials with which the committees are working and do not lend themselves to listing as specific projects. Information regarding the investigative work of such committees is, however, included in the files in the Secretary-Treasurer's office and is available for consultation.

PROJECTS ADMINISTERED BY A.S.T.M. STANDING COMMITTEES

Committee A-1 on Steel:

S 1 Concrete Reinforcement Bars (jointly with Committee C-2).
S 2 Effect on Properties of Forgings of Amount of Reduction Between Ingot and Bloom.

Committee A-2 on Wrought Iron:

S 3 Quality of Wrought Iron as Influenced by Manufacture and Heat Treatment.
S 4 Annealing of Wrought Iron Chain (jointly with Committee A-4).

Committee A-3 on Cast Iron:

S 5 Arbitration Test Bar for Cast Iron.

Committee A-4 on Heat Treatment of Iron and Steel:

S 4 Annealing of Wrought Iron Chain (jointly with Committee A-2).

Committee A-5 on Corrosion of Iron and Steel:

S 6 Atmospheric Corrosion Tests of Uncoated Sheets.
S 7 Total Immersion Tests of Uncoated Sheets.
S 8 Atmospheric Corrosion Tests of Metallic Coated Products.
S 9 Accelerated Corrosion Tests.

Committee A-8 on Magnetic Analysis:

S 10 Study of Magnetic Properties of Steel and Their Correlation with Other Properties and with General Performance.

Committee B-2 on Non-Ferrous Metals and Alloys:

S 11 Test Bars for Cast Non-Ferrous Alloys.
S 12 General Study of Properties of Babbitt Metal.

Committee B-3 on Corrosion of Non-Ferrous Metals and Alloys:

S 13 Standardization of the Practice of Corrosion-Resistance Testing.

Committee C-1 on Cement:

S 14 Compressive Strength Test of Cement Mortars.
S 15 Development of Shorter Time Strength Test.
S 16 Sulfuric Anhydride and Magnesia Content of Cement.
S 17 Study of Older and Newer Types of Hydraulic Cements.

Committee C-2 on Reinforced Concrete:

S 1 Concrete Reinforcement Bars (jointly with Committee A-1).

Committee C-3 on Brick:

S 18 Study of Test for Compressive Strength of Brick.
S 19 Present Condition of Bricks in Old Buildings.

Committee C-4 on Clay and Cement-Concrete Sewer Pipe:

S 20 Chemical Test Requirements for Sewer Pipe.

Committee C-6 on Drain Tile:

S 21 Development of Chemical Tests and Chemical Test Requirements for Drain Tile to Determine Their Resistance to the Action of Alkalies and Acids in the Soil. (In cooperation with other organizations.)

Committee C-7 on Lime:

S 22 Cause of Plasticity.

Committee C-9 on Concrete and Concrete Aggregates:

S 23 Design of Concrete.
S 36 Field Tests for Concrete.
S 37 Available Aggregates for Concrete.
S 38 Deleterious Substances in Concrete.
S 39 Admixtures.
S 40 Conditions Affecting Durability of Concrete in Structures.
S 41 Elastic Properties of Concrete.

Committee D-1 on Preservative Coatings for Structural Materials:

S 24 Paint Vehicles.
S 25 Varnish.
S 26 Turpentine and Other Paint Thinners.
S 27 Shellac.
S 28 Preparation of Iron and Steel Surfaces for Painting.
S 29 Anti-Corrosive and Anti-Fouling Paints.
S 30 Physical Properties of Paint Materials.

Committee D-11 on Rubber Products:

S 31 Performance Tests of Rubber Products.

Committee D-14 on Screen Wire Cloth:

S 32 Relative Life of Various Screen Wire Cloths.

Committee E-4 on Metallography:

S 33 Thermal Analysis of Metals.
S 34 Study of Micro-Hardness.
S 35 X-Ray Crystal Analysis.

PROJECTS ADMINISTERED BY A.S.T.M. RESEARCH COMMITTEES

R 1 Effect of Arsenic and Tin upon High-Speed Tool Steels.
R 2 Yield Point of Structural Steel.

PROJECTS ADMINISTERED BY JOINT COMMITTEES SPONSORED BY THE SOCIETY

J 1 Effect of Temperature upon the Properties of Metals. Joint committee of A.S.T.M. and A.S.M.E.
J 2 Effect of Phosphorus and Sulfur in Steel. Joint committee under the auspices of eleven organizations.
J 3 Concrete Culvert Pipe. Joint committee under the auspices of seven organizations.
J 4 Concrete and Reinforced Concrete. Joint committee under the auspices of five organizations.

In addition to the above research projects under the sole or joint auspices of the Society, the Society is represented upon the following projects under other auspices:

O 1 Molding Sand Research.
O 2 Research on Metal Springs.
O 3 Research on Rock Drill Steels.
O 4 Research on Gage Steel.
O 5 Highway Research.
O 6 Pattern Equipment Standardization.
O 7 Corrosion Committee, American Society of Refrigerating Engineers.
O 8 Corrosion Committee, National Research Council.
O 9 Welding.

The Society is also officially represented on the Division of Engineering and Industrial Research of the National Research Council.

A.S.T.M.
TENTATIVE STANDARDS

SUBMITTED OR REVISED

AT THE

1926 ANNUAL MEETING.

The term Tentative Standard is applied to a proposed Standard which is printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards its adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee whose name and address appear in the footnote to the title of each Tentative Standard.

TENTATIVE SPECIFICATIONS
FOR
OPEN-HEARTH CARBON-STEEL RAILS[1]

Serial Designation: A 1 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

I. MANUFACTURE

Mill Practices. 1. (*a*) The entire process of manufacture shall be in accordance with the best current state of the art. It is expected that thoroughly deoxidized dead setting steel will be furnished and that in every stage of manufacture strict adherence to the standards of best practice of the individual mill will be observed.

(*b*) Should anything occur in the process of manufacture, which, in the judgment of the inspector, varies detrimentally from regular care and practice, the inspector will immediately notify the chief inspector and the general superintendent of the mill, confirming such report in writing. If after full investigation, the inspector is not satisfied as to the good quality of the rails in question, and the rail, complying in other respects to these specifications, be loaded for shipment, the inspector will immediately forward a copy of this report to the purchaser.

Discard. 2. Sufficient discard shall be taken from the ingot to insure freedom from injurious segregation and pipe.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

	WEIGHT, LB. PER YD.				
ELEMENTS CONSIDERED	50–69	70–84	85–100	101–120	121–140
Carbon, per cent....	0.50 – 0.63	0.53 – 0.70	0.62 – 0.77	0.67 – 0.83	0.72 – 0.89
Manganese, per cent.	0.60 – 0.90	0.60 – 0.90	0.60 – 0.90	0.50 – 0.90	0.50 – 0.90
Phosphorus, minimum per cent....	0.04	0.04	0.04	0.04	0.04
Silicon, minimum per cent............	0.15	0.15	0.15	0.15	0.15

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

These Tentative Specifications, when adopted as standard, will supersede the present Standard Specifications for Carbon-Steel Rails (Serial Designation: A 1 – 24), 1924 Book of A.S.T.M. Standards.

Average Carbon.

4. (*a*) In any rolling, it is desired that the number of heats above the mean carbon percentage of the specific range shall be at least equal to the number of heats below the mean, and that the average carbon shall be as high as the mean.

(*b*) For information only, the manufacturer shall furnish the carbon and manganese analysis on drillings taken from both the "O" and "M" positions of the head at the top end of the "A" rail of the last full ingot rolled on each tenth heat.

Ladle Analyses.

5. Separate analyses shall be made from drillings taken from test ingots representing the second and one of the last full ingots of the heat to determine the percentages of carbon and manganese. The percentages of phosphorus, sulfur, and silicon shall be determined on equally mixed drillings from the test ingots. The average analysis of the ladle test ingots shall conform to the chemical requirements. A portion of the drillings shall be furnished to the inspector upon request for check analysis.

III. PHYSICAL PROPERTIES AND TESTS

Physical Requirements.

6. (*a*) Ductility and resistance to impact will be determined by the standard A.R.E.A. drop testing machine, with test specimens from 4 ft. to 6 ft. long cut from the top of the "A" rails from the second, middle and last full ingots of each heat. These specimens shall be marked on the base with gage marks 1 in. apart for 3 in. each side of the center of the test specimens for measuring the ductility of the metal. The distance between supports shall be 3 ft. for sections under 106 lb. For sections 106 lb. and over it shall be 4 ft.

(*b*) The temperature of the test specimens shall not exceed (38° C.) (100° F.)

Height of Drops.

7. The test specimens shall be placed head upwards on the supports and subjected to one blow from the tup falling free from the following heights:

WEIGHT OF RAIL, LB. PER YD.	HEIGHT OF DROP, FT.
50– 60, inclusive	16
61– 80, inclusive	17
81– 90, inclusive	18
91–100, inclusive	19
101–120, inclusive	20
121–140, inclusive	22

Drop Test Requirements.

8. (*a*) If all three of the specimens endure the above tests without fracture, all the rails of the melt will be accepted subject to final inspection for surface, section and finish.

(*b*) If one of the three specimens fails, all the "A" rails of the heat will be rejected. Specimens shall then be cut from the bottom end of the same "A" rails or the top end of the "B" rails and tested.

(*c*) If any of these test specimens fail, the "B" rails of the heat will be rejected. Three additional specimens shall then be taken from the bottom end of the "B" rails or the top end of the "C" rails. If all these test specimens endure the test, the balance of the heat will be accepted. If any of these test specimens fails, the entire heat shall be rejected.

Elongation and Permanent Set.

9. (*a*) One of the three test specimens shall be given a sufficient number of blows to determine, for information only, the exhausted ductility, reported inch by inch over the entire 6 in. gaged. No ductility readings will be taken between blows. The other two specimens shall be nicked and broken. The fracture of each specimen shall be examined to determine if the fracture conforms to the requirements of Section 10.

(*b*) For information only, the permanent set measured by middle ordinate in inches in a length of 3 ft. shall be recorded after the first blow on all test specimens.

(*c*) For information only, one of the three test specimens shall be tested by Brinell indentation upon the head of the rail, and the diameter of the indentation shall be entered on the test record. The ball shall be 19 mm. in diameter and the pressure 100,000 lb.

Interior Condition

10. If the fracture on any test specimen exhibits seams, laminations, cavities, interposed foreign matter, or a distinctly bright or fine-grained structure, all top rails represented shall be classified as "X-Rayls."

IV. STANDARD SECTION, LENGTH AND WEIGHT

Lengths.

11. Standard length of rails shall be 39 ft. at a temperature of 15.5° C. (60° F.) Eleven per cent of the entire order will be accepted in shorter lengths varying by 1 ft. from 38 ft. to 25 ft. A variation of $\frac{3}{8}$ in. from the specified length will be allowed, except that on 15 per cent of the order a variation of $\frac{7}{16}$ in. will be allowed.

Section.

12. The section of the rails shall conform as accurately as possible to the templets furnished by the purchaser. A variation of $\frac{1}{64}$ in. less or $\frac{1}{32}$ in. greater than the specified height will be permitted. A variation of $\frac{1}{16}$ in. in the length of either flange will be permitted, but the variation in total width of base must not exceed $\frac{1}{16}$ in. No variation will be allowed in dimensions affecting the fit of the joint bars, except that the fishing templet approved by the purchaser may stand out not to exceed $\frac{1}{16}$ in. laterally.

Weight.

13. A variation of 0.5 per cent from the calculated weight of section as applied to the entire order will be allowed.

V. WORKMANSHIP AND FINISH

Drilling. 14. Circular holes for joint bolts shall be drilled to conform to the drawings and dimensions furnished by the purchaser. A variation of $\frac{1}{32}$ in. in the size and location of bolt holes will be allowed.

Finishing. 15. (*a*) All rails shall be smooth on the heads, straight in line and without twists, waves or kinks. The supports for rails in the straightening presses shall have flat surfaces and be free from hollow places, bends or crooks, and shall be spaced not less than 60 in. When placed head up on a horizontal surface, rails that are slightly higher at the ends than the middle will be accepted, provided they contain a uniform sweep, the middle ordinate of which does not exceed $1\frac{1}{4}$ in. in 39 ft. They shall be sawed square at the ends, a variation of not more than $\frac{1}{32}$ in. being allowed, and burrs shall be entirely removed.

(*b*) Rails presented for inspection which do not conform to the requirements of Section 14 or Paragraph (*c*) may be re-conditioned by the mill, provided they can be made to fully meet the requirements.

(*c*) When any finished rail shows conditions as described in Section 10 at either end or at any drilled hole, it shall be cut back to sound metal, and accepted as an "X-Rayl."

VI. CLASSIFICATION OF RAILS

No. 1 Rails. 16. No. 1 rails shall be free from injurious defects and flaws of all kinds.

X-Rayls. 17. X-Rayls are rails as described in Sections 10 and 15 (*c*).

No. 2 Rails. 18. Rails which conform to the following requirements will be accepted as No. 2 Rails:

(*a*) Rails which do not contain surface imperfections in such number or of such character as will in the judgment of the inspector render them unfit for recognized uses.

(*b*) Rails arriving at the straightening presses with sharp kinks or greater camber than that indicated by a middle ordinate of 6 in. in 39 ft.

VII. MARKING

Marking. 19. Brands made so plain and sharp that they may be read as long as the rails are in service shall be rolled on or hot stamped into the side of the web of each rail in accordance with the following requirements and to indicate:

(*a*) Name of the manufacturer, the month and year of manufacture, and the weight and type of section of rail as rolled.

(*b*) The heat number and the ingot number as rolled shall be stamped in the web of each rail where it will not be covered by the joint bars.

(*c*) The top rails shall normally be lettered "A" and succeeding ones "B", "C", "D", "E", etc., consecutively, but in case top discard is greater than normal, the rail lettering shall conform to the amount of discard, the top rail becoming "B" or other succeeding letter to suit the condition.

(*d*) All rails shall be branded "O. H." in addition to other marks.

Classification Markings.

20. (*a*) Rails accepted as No. 2 rails shall have the ends painted white and shall be stamped with the figure 2 on both end faces.

(*b*) Rails accepted as "X-Rayls" shall have the ends painted brown and shall be stamped with the letter "X" on both end faces.

(*c*) "A" rails shall have both ends painted yellow.

(*d*) No. 1 rails less than 39 ft. long shall have both ends painted green.

(*e*) All rails of heats the carbon content of which exceeds the mean carbon percentage of the specific range shall have both ends painted blue.

Individual rails shall be painted only one color, according to the order of precedence listed above.

VIII. LOADING

Loading.

21. Rails shall be carefully handled in such manner as to avoid injury and shall be loaded as follows:

(*a*) No. 1 low-carbon rails shall be loaded in separate cars.

(*b*) No. 1 high-carbon rails shall be loaded in separate cars.

(*c*) No. 2 rails shall be loaded in separate cars.

(*d*) "X-Rayls" shall be loaded in separate cars.

(*e*) No. 1 "A" rails shall be loaded in separate cars.

(*f*) No. 1 short rails shall be loaded in separate cars. No subdivision by classification markings other than listed above is necessary for separate loading.

IX. INSPECTION AND REJECTION

Inspection.

22. Inspection and tests shall be made at the works of the manufacturer before shipment, and the works management shall afford all reasonable facilities for determining the satisfactory quality of the rails accepted.

Acceptance and Payment.

23. (*a*) In order to be accepted, the rails offered shall fulfill all the requirements of these specifications.

(*b*) No. 2 rails to the extent of 8 per cent of the whole order will be accepted.

(*c*) Rails accepted will be paid for according to actual weights.

TENTATIVE SPECIFICATIONS
FOR
THE MANUFACTURE OF OPEN-HEARTH STEEL GIRDER RAILS OF PLAIN, GROOVED AND GUARD TYPES[1]

Serial Designation: A 2 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered. 1. (*a*) These specifications are intended to cover the manufacture of open-hearth steel girder rails of plain, grooved and guard types of the classes specified.

(*b*) Girder-guard rails shall be Class A.

(*c*) Plain and grooved-girder rails under 135 lb. per yd. in weight shall be specified as either Class A or Class B.

(*d*) Plain and grooved-girder rails of 135 lb. per yd. in weight and heavier shall be Class C, unless otherwise specified.

I. MANUFACTURE

Process. 2. The steel shall be made by the open-hearth process. The entire process of manufacture and testing shall be in accordance with the best current practice.

Bled Ingots. 3. Bled ingots and ingots or blooms which show the effects of injurious treatment shall not be used.

Discard. 4. A sufficient discard from the top of each ingot shall be made at any stage of the manufacture to obtain sound rails. When finished rails show piping, they may be cut to shorter lengths until all evidence of this is removed.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 5. The steel shall conform to the following requirements as to chemical compositions, according to the class specified in the order:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

These Tentative Specifications, when adopted as standard, will supersede the present Standard Specifications for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (Serial Designation: A 2 – 24), 1924 Book of A.S.T.M. Standards.

	CLASS A	CLASS B	CLASS C
Carbon, per cent....	0.60 - 0.75	0.70 - 0.85	0.75 - 0.90
Manganese, per cent.	0.60 - 0.90	0.60 - 0.90	0.60 - 0.90
Silicon, per cent.....	0.15 - 0.40	0.15 - 0.40	0.15 - 0.40
Phosphorus, per cent.	not over 0.04	not over 0.04	not over 0.04

Ladle Analyses.

6. To determine whether the material conforms to the requirements specified in Section 5, an analysis shall be made by the manufacturer from a test ingot taken during the pouring of each melt. Drillings for analysis shall be taken not less than ⅛ in. beneath the surface of the test ingot. A copy of this analysis shall be given to the purchaser or his representative.

Check Analyses.

7. A check analysis may be made as information from time to time by the purchaser from a test ingot or drillings therefrom furnished by the manufacturer.

III. PHYSICAL PROPERTIES AND TESTS

Impression Test Specimens.

8. (*a*) Four representative sections of rail from each melt shall be selected by the inspector as test specimens.

(*b*) Excess scale on the head or web of the sections shall be carefully removed.

Impression Test.

9. (*a*) The head of each specimen shall be subjected to a pressure of 100,000 lb. (45,359 kg.) for a period of 15 seconds, applied through a hardened steel ball 0.75 in. (19.05 mm.) in diameter.

(*b*) *Test Balls.*—The steel test ball shall have a minimum Brinell hardness of 600 and it shall not be possible to attack the surface of the ball with an American Swiss Pillar File No. 2.

(*c*) *Permissible Variation in Test Balls.*—When fractured, the ball shall show a fine uniform grain, and the fracture shall resist file attack for at least one-third of its depth from the surface of the ball. The permissible variation in the diameter of the ball shall not be greater than 0.002 in. over or under the standard size, and the permanent deformation under the required loading shall not be greater than 0.003 in.

(*d*) *Depth of Impressions.*—The average depth of impression obtained on the four specimens shall not be more than 0.1496 in. (3.8 mm.) for Class A rails, 0.1391 in. (3.5 mm.) for Class B rails, and 0.1338 in. (3.4 mm.) for Class C rails.

Retests.

10. If the average of the impression tests on the head of the section from any melt fails to conform to the requirements specified in Section 9 (*d*) the manufacturer may at his option test each rail from such melt by making an impression test on the web, as described in Section 9 (*a*). Rails so retested which conform to the requirements as to depths of impression specified in Section 9 (*d*) shall be accepted.

IV. STANDARD SECTIONS, LENGTHS, AND WEIGHTS

Section. 11. (*a*) The cold templet of the manufacturer shall conform to the specified section as shown in detail on the drawing of the purchaser and shall at all times be maintained perfect.

(*b*) The section of the rail shall conform as accurately as possible to the templet, and within the following permissible variations:

(1) The height shall not vary more than $\frac{1}{64}$ in. under nor more than $\frac{1}{32}$ in. over that specified.

(2) The overall width of head and tram shall not vary more than $\frac{1}{8}$ in. from that specified. Any variation which would affect the gage line more than $\frac{1}{32}$ in. will not be allowed.

(3) The overall width of base shall not vary more than $\frac{1}{8}$ in. under that specified for widths less than $6\frac{1}{2}$ in., $\frac{3}{16}$ in. under for a width of $6\frac{1}{2}$ in., and $\frac{1}{4}$ in. under for a width of 7 in.

(4) Any variation which would affect the fit of the splice bars will not be allowed.

(5) The base of the rail shall be at right angles to the web; and the convexity shall not exceed $\frac{1}{32}$ in.

(*c*) When necessary on account of the type of track construction, and notice to that effect has been given to the manufacturer, special care shall be taken to maintain the proper position of the gage line with respect to the outer edge of the base.

Length. 12. (*a*) Unless otherwise specified, the lengths of rails at a temperature of 60° F. (15.5° C.) shall be 60 and 62 ft. for those sections in which the weight per yard will permit; except girder-guard rails which shall be 30 and 32 ft., unless otherwise specified.

(*b*) The lengths shall not vary more than $\frac{1}{4}$ in. from those specified.

(*c*) Shorter lengths, varying by one foot down to 40 ft. for plain and grooved-girder rails and 24 ft. for girder-guard rails, will be accepted to the extent of 10 per cent by weight of each class on the order.

Weight. 13. (*a*) The weight of the rails per yard as specified in the order shall be maintained as nearly as possible after conforming to the requirements specified in Section 11.

(*b*) The total weight of an order shall not vary more than 0.5 per cent from that specified.

(*c*) Payments shall be based on actual weights.

V. WORKMANSHIP AND FINISH

Straightening. 14. (*a*) Rails on the hot beds shall be protected from water or snow and shall be carefully handled to minimize cold-straightening.

(*b*) The distance between the rail supports in the cold-straightening presses shall not be less than 42 in., except as may be necessary near the ends of the rails. The gag shall have rounded corners to avoid injury to the rails.

(*c*) Rails heard to snap or check while being straightened shall be at once rejected.

15. (*a*) Rails shall be smooth on the head, straight in line and surface without any twists, waves, or kinks, particular attention being given to having the ends without kinks or droop. **Finish.**

(*b*) All burrs or flow caused by drilling or sawing shall be carefully removed.

(*c*) Rails shall be free from gag marks and other injurious defects of cold-straightening.

(*d*) Any rails to be cold-straightened showing sharp kinks or greater camber than that indicated by the middle ordinate of 18 in. in 60 ft. shall be classed as No. 2 rails.

VI. DRILLING, MILLING AND PUNCHING

16. Circular holes for splice bar bolts, bonds and tie rods shall be drilled to conform to the drawings and dimensions furnished by the purchaser and within the following permissible variations: **Drilling.**

(*a*) The diameter of bolt holes shall not vary more than $\frac{1}{32}$ in. over or under that specified. The diameter of bond holes shall not be over the size specified, but may be $\frac{1}{32}$ in. under. The diameter of the tie rod holes shall not be less than that specified but may be $\frac{1}{16}$ in. over.

(*b*) The location of bolt and bond holes shall not vary more than $\frac{1}{16}$ in. either longitudinally or vertically from that specified. The location of the tie rod holes shall not vary more than $\frac{1}{4}$ in. vertically and not more than $\frac{1}{2}$ in. longitudinally from that specified.

(*c*) Bond holes shall be truly cylindrical and not conical.

17. The ends of the rail shall be milled. The plane of the finished end surface shall, in the direction of the width of the rail, be at right angles to the gage with a permissible variation of $\frac{1}{32}$ in. in 6 in. and, in the direction of the height of the rail, be inclined to the plane of the base so that the top edge of the head will project beyond the bottom edge of the base not less than $\frac{1}{32}$ in. nor more than $\frac{3}{32}$ in. **Milling.**

18. Unless otherwise specified by the purchaser, the tie rod holes in Class A rails may be punched, and, when so made, they shall be free from burrs, fins, etc. Punched tie-rod holes shall not be less in diameter than specified, but may be $\frac{1}{8}$ in. over size. **Punching.**

VII. CLASSIFICATION OF RAILS

19. Rails which are free from injurious defects and flaws of all kinds shall be classed as No. 1 rails. **No. 1 Rails**

No. 2 Rails. 20. (*a*) Rails which are rough on the head or which by reason of surface or other imperfections are not classed as No. 1 rails, shall be classed as No. 2 rails; provided they do not, in the judgment of the inspector, contain imperfections in such number and of such character as to render them unfit for No. 2 rail uses, and provided they conform to the requirements specified in Section 11.

(*b*) No. 2 rails will be accepted to the extent of 10 per cent by weight of the entire order.

VIII. MARKING AND LOADING

Marking. 21. (*a*) The name or brand of the manufacturer, the year and month of manufacture, the letters "O.H.," the weight of the rail, and the section number, shall be legibly rolled in raised letters and figures on the web. The melt number shall be legibly stamped on each rail where it will not be covered subsequently by the splice bars.

(*b*) Both ends of all short-length No. 1 rails shall be painted green. Both ends of all No. 2 rails shall be painted white and shall have two heavy center-punch marks on the web at each end at such a distance from the end that they will not be covered subsequently by the splice bars.

Loading. 22. (*a*) Rails shall be loaded in the presence of the inspector, and shall be handled in such a manner as not to bruise the flanges or cause other injuries.

(*b*) Rails of each class shall be placed together in loadings.

(*c*) Rails shall be paired as to length before shipment.

IX. INSPECTION

Inspection. 23. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

TENTATIVE SPECIFICATIONS
FOR
SOFT STEEL TRACK SPIKES[1]

Serial Designation: A 65 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

I. MANUFACTURE

Process

1. The steel shall be made by either or both of the following processes: Bessemer or open-hearth.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition

2. (*a*) The steel shall conform to the following requirements as to chemical composition:

	BESSEMER	OPEN-HEARTH
Carbon, minimum per cent	0.06	0.12

Ladle Analyses.

3. (*a*) A carbon determination shall be made of each melt of bessemer steel and three determinations shall be made every 24 hours, one for each 8-hour turn respectively representing the average carbon content in the steel. These analyses shall be made from drillings taken at least ⅛ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentage of carbon. This analysis shall be made from drillings taken at least ⅛ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

These Tentative Specifications, when adopted as standard, will supersede the present Standard Specifications for Steel Track Spikes (Serial Designation: A 65 – 24), 1924 Book of A.S.T.M. **Standards.**

III. PHYSICAL PROPERTIES AND TESTS

Bend Tests.

4. (*a*) The body of the full-size finished spikes shall stand being bent cold through 180 deg. flat on itself, without cracking on the outside of the bent portion.

(*b*) The head of the full-size finished spikes shall stand being bent backward to the line of the face of the spike, without cracking on the outside of the bent portion.

Number of Tests.

5. One bend test of each kind shall be made from each lot of 5 tons or fraction thereof.

IV. WORKMANSHIP AND FINISH

Workmanship.

6. The spikes shall conform to the dimensions specified by the purchaser with the following permissible variations:

(*a*) A variation of $\frac{1}{32}$ in. over and $\frac{1}{64}$ in. under the specified cross-section dimensions of the body of the spike will be permitted.

(*b*) A variation of $\frac{3}{32}$ in. over and $\frac{1}{32}$ in. under the specified dimensions of the head of the spike will be permitted.

(*c*) A variation of $\frac{1}{8}$ in. from the specified length of the spike measured from the under size of the head to the point will be permitted.

(*d*) A variation of one degree in the specified angle of the under side of the head of the spike will be permitted.

Finish.

7. The finished spikes shall be free from injurious defects and shall have a workmanlike finish.

V. INSPECTION AND REJECTION

Inspection.

8. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the spikes ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy himself that the spikes are being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

9. Spikes which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

TENTATIVE SPECIFICATIONS
FOR
STEEL TIE PLATES[1]

Serial Designation: A 67 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1916; REVISED, 1917, 1918, 1920, 1926.

Material Covered.

1. These specifications cover two grades of steel tie plates: namely, soft and medium. The soft grade will be used unless otherwise specified.

I. MANUFACTURE

Process.

2. The steel shall be made by either or both the following processes: Bessemer or open-hearth.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. (*a*) The steel shall conform to the following requirement as to limitation of phosphorus content:

	BESSEMER	OPEN-HEARTH
Phosphorus, not over............	0.10 per cent	0.05 per cent

(*b*) Unless otherwise specified, the steel shall be furnished according to chemical composition only, in which case the minimum carbon content shall be as follows:

	BESSEMER	OPEN-HEARTH
Soft grade, not under............	0.08 per cent	0.15 per cent
Medium grade, not under........	0.12 "	0.20 "

Ladle Analyses.

4. (*a*) A carbon determination shall be made of each melt of bessemer steel, and three analyses every 24 hours representing the average of the elements carbon and phosphorus contained in the steel, one for each 8-hour turn respectively. These analyses shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

representative, and shall conform to the requirements specified in Section 3.

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon and phosphorus. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses. 5. An analysis may be made by the purchaser from a finished tie plate representing each melt of open-hearth steel, and each melt or lot of 10 tons of bessemer steel. The carbon content thus determined shall not be less than that specified in Section 3, and the phosphorus content shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS

Bend Tests. 6. The bend test specimens specified in Section 7 shall stand being bent cold through 180 deg. around a pin the diameter of which is equal to the thickness of the specimen for the soft grade, and to twice the thickness of the specimen for the medium grade, without cracking on the outside of the bent portion.

Test Specimens. 7. Bend test specimens shall be taken from the finished tie plates, or from the rolled bars, and longitudinally with the rolling. They shall be rectangular in section, not less than $\frac{1}{2}$ in. in width between the planed sides, and shall have two faces as rolled. They shall be free from ribs or projections. Where the design of the tie plates is such that the specimen cannot be taken between the ribs or projections, these ribs or projections shall, in preparing the specimen, be planed off even with the main surface of the tie plate.

Optional Bend Tests. 8. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 6:

A piece of the rolled bar shall stand being bent cold through 90 deg. around a pin the diameter of which is equal to the thickness of the section where bent for the soft grade, and to twice the thickness of the section where bent for the medium grade, without cracking on the outside of the bent portion.

Number of Tests. 9. (*a*) One bend test shall be made from each melt of open-hearth steel, or from each melt or lot of 10 tons of bessemer steel.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

IV. WORKMANSHIP AND FINISH

Permissible Variations. 10. The tie plates shall conform to the dimensions specified by the purchaser, with the following permissible variations:

(*a*) For plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{1}{8}$ in. in rolled width, and $\frac{3}{16}$ in. in sheared length will be permitted.

(*b*) For plates with shoulders perpendicular to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{3}{16}$ in. in rolled width, and $\frac{1}{4}$ in. in sheared length will be permitted. The distance from the face of shoulder to the outside end of the plate shall not vary more than $\frac{1}{8}$ in., and from the face of shoulder to the inside end not more than $\frac{1}{4}$ in.

(*c*) A variation of not more than $\frac{1}{32}$ in. in the location of spike holes and in the length of their sides will be permitted.

11. The tie plate shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearings for the rail.

Finish. 12. The finished tie plates shall be free from burrs and other surface deformities caused by the shearing and punching; they shall also be free from other injurious defects and shall have a workmanlike finish.

V. MARKING

Marking. 13. The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

VI. INSPECTION AND REJECTION

Inspection. 14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 15. Unless otherwise specified, any rejections based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

16. Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 17. Samples tested in accordance with Section 5, which represent rejected tie plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the result of the tests the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR
CARBON-STEEL CASTINGS FOR VALVES, FLANGES AND FITTINGS FOR HIGH-TEMPERATURE SERVICE[1]

Serial Designation: A 95 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1925; Revised, 1926.

Material Covered. 1. These specifications cover carbon-steel castings for valves, flanges and fittings for high-temperature service (Note 1).

I. MANUFACTURE

Process. 2. The steel shall be made by one or more of the following processes: open-hearth, electric-furnace, converter, or crucible.

Heat Treatment. 3. (*a*) All castings shall receive a heat treatment proper to the design and chemical composition of the castings.

(*b*) Heat treatment, unless otherwise specified by the purchaser, may consist of annealing, or of normalizing, or of normalizing followed by annealing, or of normalizing followed by a draw-back to a temperature below the critical range. No castings which have been quenched in any liquid medium shall be offered under these specifications.

(*c*) *Annealing.*—The procedure for annealing shall consist in allowing the castings to cool, after pouring, to a temperature below the critical range. They shall then be uniformly reheated to the proper temperature to refine the grain and allowed to cool uniformly in the furnace.

(*d*) *Normalizing.*—The procedure for normalizing shall consist in allowing the castings to cool, after pouring, to a temperature below the critical range. They shall then be reheated to the proper temperature to refine the grain and allowed to cool in still air.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 4. (*a*) The castings shall conform to the following requirements as to chemical composition, except that the following limitations for carbon, manganese and silicon are intended to show desired composition and are not to be used for rejection:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Carbon	0.15 – 0.40 per cent
Manganese	not under 0.50 "
Silicon	not under 0.20 "
Phosphorus	not over 0.05 "
Sulfur	not over 0.05 "

(*b*) Manufacturers submitting proposals to furnish material under these specifications shall specify, with their proposals, the limits of carbon, manganese and silicon which they will accept as a basis for rejection.

Ladle Analyses. 5. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 4. This analysis shall be made from drillings taken at least ¼ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative and shall conform to the requirements specified in Section 4.

Check Analyses. 6. Analyses may be made by the purchaser from the broken tension test specimen or from a casting representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 4. Samples for analysis shall be taken not less than ¼ in. beneath the surface, except in the case of castings which are too thin, and shall be taken in such a manner as not to impair the usefulness of the casting.

III. PHYSICAL PROPERTIES AND TESTS

Tension Tests. 7. (*a*) The castings shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in	70 000
Yield point, lb. per sq. in	36 000
Elongation in 2 in., per cent	22
Reduction of area, per cent	30

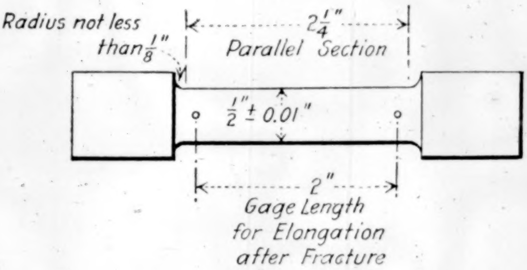
(*b*) The yield point shall be determined by the drop of the beam of the testing machine at a cross-head speed not to exceed ⅛ in. per minute. The tensile strength shall be determined at a speed not to exceed 1½ in. per minute.

Bend Test. 8. (*a*) Bend tests shall be required for castings only when so specified in the order.

(*b*) When a bend test is specified, the test specimens shall stand being bent cold through an angle of 90 deg. around a pin 1 in. in diameter, without cracking on the outside of the bent portion.

Test Specimens.

9. (*a*) Tension test specimens, and, when a bend test is specified, bend test specimens, shall be taken from test bars cast attached to the castings where practicable. If the design of the castings is such that test bars should not be attached to the castings, the test bars shall be cast attached to special blocks, a sufficient number of which shall be provided for each lot of castings. Test bars from which tension and bend test specimens are to be taken shall remain attached to the castings or blocks they represent through heat treatment and until presented for inspection. Test bars shall be provided in sufficient numbers to furnish the tests required in Section 10.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.

(*b*) If satisfactory to the manufacturer and inspector, tension test specimens may be cut from heat-treated castings, instead of from test bars.

(*c*) Tension test specimens shall conform to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*d*) Bend test specimens shall be machined to 1 by ½ in. in section with the corners rounded to a radius of not over $\frac{1}{16}$ in.

Number of Tests.

10. (*a*) One tension test and, when specified, one bend test shall be made from each melt in each heat-treatment charge and, when specified, from each casting weighing 500 lb. or over.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case another specimen from the same lot shall be substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 7 (*a*) and any part of the fracture is more than ¾ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests. 11. If the results of the physical tests for any lot do not conform to the requirements specified, such lot may be re-treated, but not more than twice. Retests shall be made as specified in Sections 7 and 8.

IV. WORKMANSHIP AND FINISH

Workmanship. 12. The castings shall conform substantially to the shapes and sizes indicated by the patterns and drawings submitted by the purchaser.

Finish. 13. (*a*) The castings shall be free from injurious defects.

Welding. (*b*) Defects which do not impair the strength of the castings may be welded by an approved process. The defects shall be cleaned out to solid metal, before welding, and when so required by the inspector, shall be submitted to him in this condition for his approval. All castings shall be heat-treated after welding in accordance with the requirements in Section 3.

V. INSPECTION AND REJECTION

Inspection. 14. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the castings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the castings are being furnished in accordance with these specifications.

(*b*) If, in the case of important castings for special purposes, surface inspection in the green state is required, this shall be so specified in the order.

(*c*) All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 15. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples.

(*b*) Castings which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected and the manufacturer shall be notified.

Rehearing. 16. Samples tested in accordance with Section 6, which represent rejected castings, shall be preserved for two weeks from the date of transmission of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures up to 750° F. (400° C.); or at the discretion of the designing engineer higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the sponsorship of the Heating and Piping Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry and the American Society of Mechanical Engineers, and organized under the procedure of the American Engineering Standards Committee.

TENTATIVE SPECIFICATIONS
FOR
FORGED OR ROLLED STEEL PIPE FLANGES FOR HIGH-TEMPERATURE SERVICE[1]

Serial Designation: A 105 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered.

1. (*a*) These specifications cover forged or rolled steel flanges to be attached to piping for high temperature service (Note 1).

(*b*) Three classes of material are covered, designated Class A, B and C respectively. Class A is intended for forge welding and is classified by the chemical properties as specified in Section 6 (*a*) and (*b*). Classes B and C are classified in accordance with their physical properties as specified in Section 9 (*a*).

Certification of Test.

2. Unless otherwise specified on the order, a certification that the material conforms to the requirements of these specifications shall be the basis of acceptance of the material.

I. MANUFACTURE

Process.

3. The steel may be made by either or both of the following processes: Open-hearth or electric furnace.

Discard.

4. A sufficient discard shall be made from each ingot to secure freedom from injurious piping and undue segregation.

Heat Treatment.

5. (*a*) Class A steel does not require heat treatment.

(*b*) Classes B and C steels shall be heat treated. Heat treatment may consist of annealing or normalizing.

Annealing.

(*c*) The procedure for annealing shall consist in allowing the flanges, immediately after forging or rolling, to cool to a temperature below the critical range, under suitable conditions to prevent injuries by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as an "annealing charge") and allowed to cool uniformly in the furnace.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Normalizing. (*d*) The procedure for normalizing shall consist in allowing the flanges, immediately after forging or rolling, to cool to a temperature below the critical range, under suitable conditions to prevent injuries by too rapid cooling. They shall then be uniformly reheated to the proper temperature to refine the grain (a group thus reheated being known as a "normalizing charge") and allowed to cool in still air.

(*e*) No flanges which have been quenched in any liquid medium shall be offered under these specifications.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 6. (*a*) The steel shall conform to the following requirements as to chemical composition:

	CLASS A	CLASSES B AND C
Manganese, per cent	0.35 - 0.60	0.40 - 0.80
Phosphorus, per cent	not over 0.05	not over 0.05
Sulfur, per cent	not over 0.05	not over 0.05

(*b*) The carbon content of Class A material shall not exceed 0.17 per cent. The carbon content of Classes B and C shall be a matter of agreement between the purchaser and the manufacturer.

Ladle Analysis. 7. An analysis of each melt of steel shall be made by the manufacturer to determine the percentage of the elements specified in Section 6.

Check Analysis. 8. (*a*) An analysis may be made by the purchaser from one forged or rolled flange representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 6, except that phosphorus and sulfur may not exceed 0.055 per cent.

(*b*) All drillings for analysis shall be taken at least ¼ in. below the surface, or turnings may be taken from test specimens.

III. PHYSICAL PROPERTIES AND TESTS

Tension Tests. 9. (*a*) Forged or rolled steel flanges shall conform to the following minimum requirements as to tensile properties:

	FLANGES NOT FOR FORGE WELDING	
	CLASS B	CLASS C
Tensile strength, lb. per sq. in	60 000	70 000
Yield point, lb. per sq. in	30 000	36 000
Elongation in 2 in, per cent	25.0	22.0
Reduction of area, per cent	38.0	30.0

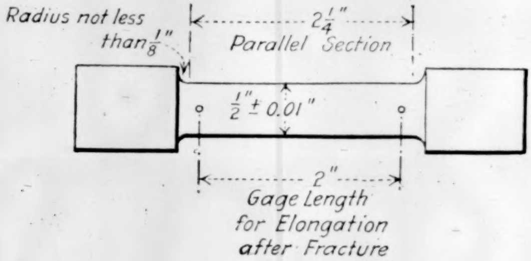
(*b*) The yield point shall be determined by the drop of the beam of the testing machine, or by dividers, at a speed of head of the testing machine not to exceed $\frac{1}{8}$ in. per minute. The tensile strength shall be determined at a speed of head not to exceed $1\frac{1}{2}$ in. per minute.

Number of Tests. 10. (*a*) For classes B and C, one tension test shall be made from each melt or for each annealing or normalizing charge. If more than one melt is represented in any annealing or normalizing charge, a test shall be made from each melt.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any test specimen is less than that specified in Section 9 (*a*) and any part of the fracture is more than $\frac{3}{4}$ in. from the center of the gage length, as indicated by scribe scratches marked on the specimen before testing, a re-test shall be allowed.

(*d*) For purposes of testing, the necessary extra flanges shall be provided to furnish the specimens required in Paragraph (*a*). The test specimen shall be cut tangentially from the flange portion approximately midway between the inner and outer surfaces and approximately midway between the front and back faces.


Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1

Tension Test Specimens. 11. (*a*) The tension test specimens taken from the flanges shall conform to the dimensions shown in Fig. 1, except as specified in Paragraph (*b*). The ends shall be of a form to fit the holders of the testing maching in such a way that the load shall be axial.

(*b*) In the case of small sections which will not permit of taking the standard test specimen specified in Paragraph (*a*), the tension test specimen shall be as large as feasible and its dimensions shall be proportional to those shown in Fig. 1. The gage length for measuring elongation shall be four times the diameter of the specimen.[1]

Retests. 12. If any of the results of the physical tests of any test lot do not conform to the requirements specified, the manufacturer may re-treat such lots one or more times and retests shall be made as specified in Section 10 (*a*).

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[1] These requirements are in accordance with the provisions of Section 5 of the Tentative Methods of Tension Testing of Metallic Materials (Serial Designation: E 8 – 25 T). *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 854 (1925); also 1925 Book of A.S.T.M. Tentative Standards, p. 954.

IV. WORKMANSHIP AND FINISH

13. (*a*) The flanges shall conform to the sizes and shapes specified by the purchaser. **Workmanship.**

(*b*) The flanges shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING

14. Identification marks shall be stamped legibly on each flange. **Identification.**

VI. INSPECTION AND REJECTION

15. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the flanges ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the flanges are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment and shall be so conducted as not to interfere unnecessarily with the operation of the works. **Inspection.**

16. (*a*) Unless otherwise specified, any rejection based on tests shall be reported within five working days from the receipt of samples. **Rejection.**

(*b*) Flanges which show injurious defects while being finished shall be rejected.

17. Samples tested in accordance with Section 8, which represent rejected flanges, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

EXPLANATORY NOTES

NOTE 1.—This contemplates temperatures up to 750° F. (400° C.), or at the discretion of the designing engineer, higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards for pressures and temperatures formulated by the Sectional Committee on Standardization of Pipe Flanges and Fittings, under the sponsorship of the Heating and Piping Contractors National Association, Manufacturers Standardization Society of the Valve and Fittings Industry, and The American Society of Mechanical Engineers, and organized under the procedure of the American Engineering Standards Committee.

TENTATIVE SPECIFICATIONS

FOR

LAP-WELDED AND SEAMLESS STEEL PIPE FOR HIGH-TEMPERATURE SERVICE[1]

Serial Designation: A 106 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered. 1. These specifications cover lap-welded and seamless steel pipe for 250, 400, 600, 900 and 1350 lb. pressure and high temperatures (Note 1). Pipe ordered under these specifications must be suitable for bending, flanging and such forming operations (Note 2).

I. MANUFACTURE

Process. 2. (*a*) The steel for lap-welded pipe shall be of soft weldable quality made by the open-hearth process. The steel for seamless pipe may be made by either or both of the following processes: Open-hearth or electric furnace.

(*b*) Welded pipe 2 in. or over in nominal diameter shall be made by the lap-weld process. All pipe $1\frac{1}{2}$ in. or under in nominal diameter shall be made by the seamless process.

(*c*) Unless otherwise specified, seamless pipe shall be furnished hot finished or annealed.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The steel for welded and seamless pipes shall conform to the following requirements as to chemical composition:

	WELDED	SEAMLESS
Phosphorus, per cent..........	not over 0.06 (Note 3)	not over 0.04
Sulfur, per cent..............	" " 0.05	" " 0.05

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

III. PHYSICAL PROPERTIES AND TESTS

Tension Tests.

4. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	Welded	Seamless Low Carbon	Seamless Medium Carbon
Tensile strength, lb. per sq. in....	45 000	47 000	62 000
Yield point, lb. per sq. in........	25 000	27 000	35 000
Elongation in 2 in., per cent.....	40	40	25

(*b*) The yield point shall be determined by the drop of the beam of the testing machine, or by the use of dividers.

Hydrostatic Tests.

5. Pipe shall withstand the hydrostatic test pressures specified in the following table. Welded pipe shall be struck near both ends, while under pressure, with a 2-lb. hammer or equivalent.

Class of Pipe, Working Pressure, lb. per sq. in.	Standard Test Pressure, lb. per sq. in.
250	750
400	1000
600	1500
900	2000
1350	3000

NOTE.—The test pressures given above are the minimum test pressures desired on the finished product, and, wherever feasible, the mill is to test at least up to these pressures. In the case of sizes of pipe which require flanges or special end connections for routine testing under high pressure, unless otherwise stated in the order, the mill is to test at the highest pressure which is feasible for that size of pipe, without special equipment. The purchaser may then apply the standard test pressure (as above) to the fabricated pipe and this test is to have the same significance as though it had been applied at the mill.

Flattening Tests.

6. For welded pipe 2 in. or more in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.

Bend Tests.

7. For pipe 2 in. or under in diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is twelve times the nominal diameter of the pipe without developing cracks, and in the case of welded pipe, without opening up at the weld.

Test Specimens.

8. (*a*) Test specimens shall consist of sections cut from a pipe. Specimens for the flattening test shall be smooth on the ends and free from burrs.

(*b*) Tension test specimens shall be cut longitudinally from the pipe and not flattened. Their widths shall be not less than the wall thickness of the pipe nor more than three times the wall thickness. The sides of specimens shall be parallel between gage marks. If desired, the tension test specimen may consist of full section of the pipe.

(*c*) All specimens shall be tested at room temperature.

Number of Tests. 9. (*a*) From each lot of 500 lengths or less, of each size, two lengths shall be selected for test. Upon one of these the tension test specified in Section 4 shall be made. Upon both of them, the tests specified in Sections 6 or 7 shall be made.

(*b*) Each length shall be subjected to the hydrostatic test.

Retests. 10. If the results of any physical or chemical tests of any lot do not conform to the requirements specified in Sections 4, 6, and 7, retests of double the number of additional pipes shall be made, each of which shall conform to the requirements specified.

IV. STANDARD WEIGHTS

Standard Weights. 11. (*a*) The standard weights and nominal thicknesses for pipe of various diameters are given in Table I.

(*b*) Nipples shall be cut from pipe of the same weight and quality as described in these specifications.

Permissible Variations. 12. The weight of the pipe shall not exceed that specified in Table I by more than 5 per cent for the 250, 400, 600 and 900-lb. standards, nor more than 10 per cent for the 1350-lb. standard.

Lengths. 13. Unless otherwise specified, pipe shall be furnished as to lengths in accordance with the following regular practice:

(*a*) The 250 and 400-lb. pipe shall be in unjointed random lengths of 16 to 22 ft. when ordered with plain ends, 5 per cent may be in lengths of 12 to 16 ft.

(*b*) The 600, 900 and 1350-lb. standard pipe shall be in unjointed random lengths of 12 to 22 ft.

V. WORKMANSHIP AND FINISH

Workmanship. 14. (*a*) For pipe $1\frac{1}{2}$ in. or under in inside diameter, the outside diameter at any point shall not vary more than $\frac{1}{64}$ in. over, nor more than $\frac{1}{32}$ in. under the standard size. For pipe 2 in. or over in inside diameter, the outside diameter shall not vary more than 1 per cent over or under the standard size.

(*b*) The minimum wall thickness at any point for welded, and seamless pipe shall not be more than 12.5 per cent under the nominal wall thickness specified.

TABLE I.—DIMENSIONS AND WEIGHTS OF PIPE FOR 250, 400, 600, 900 and 1350 LB. STANDARDS FOR HIGH TEMPERATURES.

Nominal Pipe Size, in.	Outside Diameter, in.	Threads per in.	250 lb.		400 lb.		400 lb.		600 lb.		900 lb.		1350 lb.	
			Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends, lb.	Wall Thickness, in.	Weight per Lineal Foot, Plain Ends.
			SEAMLESS OPEN-HEARTH PIPE				SEAMLESS OPEN-HEARTH PIPE							
½	0.840	14	0.109	0.850	....	....	0.109	0.850	0.147	1.087	0.147	1.087	0.147	1.087
¾	1.050	14	0.113	1.130	....	....	0.113	1.130	0.154	1.473	0.154	1.473	0.1875	1.727
1	1.315	11½	0.133	1.678	....	....	0.133	1.678	0.179	2.171	0.179	2.171	0.21875	2.561
1¼	1.660	11½	0.140	2.272	....	....	0.140	2.272	0.191	2.996	0.191	2.996	0.250	3.764
1½	1.900	11½	0.145	2.717	....	....	0.145	2.717	0.200	3.631	0.200	2.631	0.28125	4.862
			LAP-WELDED OPEN-HEARTH PIPE				SEAMLESS OPEN-HEARTH PIPE							
2	2.375	11½	0.154	3.652	0.218	5.022	0.167	3.938	0.1875	4.380	0.250	5.673	0.3125	6.883
2½	2.875	8	0.203	5.793	0.276	7.661	0.203	5.793	0.217	6.160	0.276	7.661	0.375	10.012
3	3.500	8	0.216	7.575	0.300	10.252	0.216	7.575	0.241	8.388	0.3125	10.638	0.40625	13.423
3½	4.000	8	0.226	9.109	0.318	12.505	0.226	9.109	0.28125	11.170	0.34375	13.423	0.46875	17.678
4	4.500	8	0.237	10.790	0.337	14.983	0.237	10.790	0.28125	12.672	0.375	16.520	0.500	21.360
5	5.563	8	0.258	14.617	0.375	20.778	0.258	14.617	0.352	19.590	0.4375	23.949	0.625	32.961
6	6.625	8	0.280	18.974	0.432	28.573	0.288	19.491	0.385	25.658	0.500	32.707	0.6875	43.596
8	8.625	8	0.322	28.554	0.500	43.388	0.34375	30.402	0.46875	40.832	0.625	53.400	0.875	72.424
10	10.750	8	0.365	40.483	0.500	54.735	0.395	43.684	0.53125	57.979	0.750	80.101	1.0625	109.930
12	12.750	8	0.375	49.562	0.500	65.415	0.500	65.415	0.625	80.935	0.875	110.973	1.21875	150.095
14	14	8	0.40625	58.980	0.625	89.279	0.500	72.091	0.65625	93.524	0.9375	130.790	1.34375	181.635
16	16	8	0.46875	77.754	0.6875	112.433	0.53125	87.771	0.750	122.154	1.03125	164.864	1.500	232.293
18	18	8	0.500	93.451	0.750	138.174	0.59375	110.379	0.8125	149.146	1.15625	208.002	1.6875	293.996
20	20	8	0.5625	116.772	0.875	178.725	0.625	129.330	0.90625	184.806	1.28125	256.146	1.84375	357.524
24	24	8	0.625	163[a]	0.9375	240[a]	0.750	186.235	1.03125	252.975	1.500	360.455	2.1875	509.602
SPECIAL SIZES			LAP-WELDED OPEN-HEARTH PIPE				SEAMLESS OPEN-HEARTH PIPE							
4½	5.000	8	0.247	12.538	0.355	17.611	0.250	12.682	0.3125	15.644	0.40625	19.931	0.5625	26.658
7	7.625	8	0.301	23.544	0.500	38.048	0.3125	24.405	0.40625	31.320	0.5625	42.428	0.78125	57.105
9	9.625	8	0.342	33.907	0.500	48.728	0.375	37.046	0.500	48.728	0.6875	65.624	0.96875	89.561
15	15	8	0.4375	68.044	0.625	95.954	0.500	77.431	0.6875	105.091	1.000	149.522	1.40625	204.164
17	17	8	0.500	88.111	0.6875	119.776	0.5625	98.749	0.78125	135.327	1.09375	185.807	1.59375	262.237
22	22	8	0.625	148[a]	0.875	204[a]	0.6875	156.489	0.96875	217.597	1.375	302.882	2.000	427.206

[a] Hammer weld pipe approximate manufacturing weight.

Ends. 15. Unless otherwise specified, pipe shall conform to the following regular practice:

(*a*) Each end of all pipe of $2\frac{1}{2}$-in. nominal diameter or under shall be threaded, unless otherwise specified.

(*b*) All pipe of 3-in. nominal diameter and over shall be furnished with plain ends, unless otherwise specified.

Threads. (*c*) All threads shall be in accordance with the American Standard (Note 4) and cut so as to make a tight joint when the pipe is tested at the mill to the specified internal hydrostatic pressure. The variation from the standard, when tested with the standard working gage, shall not exceed a maximum of one and one-half turns either way.

Couplings. (*d*) Each length of threaded pipe shall be provided with one coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings shall be made of steel. The threads on the other end of the pipe shall be protected from damage in transit by a suitable half coupling or thread protector.

Finish. 16. The finished pipe shall be reasonably straight and free from injurious defects. All burrs at the ends of the pipe shall be removed.

VI. MARKING

Marking. 17. Each length of pipe shall be marked with appropriate symbols to show by whom manufactured, the year, and that it conforms to these specifications.

VII. INSPECTION AND REJECTION

Inspection. 18. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the pipe is being furnished in accordance with these specifications. All tests and inspection shall be made at the place of manufacture prior to shipment and at the manufacturer's expense, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 19. Each length of pipe which develops injurious defects in shop working or application shall be rejected, and the manufacturer notified.

Explanatory Notes

Note 1.—This contemplates temperatures up to 750° F. (400° C.), or at the discretion of the designing engineer, higher temperatures with appropriate pressures may be used. Reference may be made to the dimensional standards reproduced in Table I for various pressures at this high temperature formulated at the suggestion of Sub-Committee No. 3 on Steel Flanges and Flanged Fittings of the Sectional Committee on Pipe Flanges and Fittings. This table is to be published as an appendix to the report of Sub-Committee No. 3 and, under the procedure of the American Engineering Standards Committee, will in due course be presented for approval as a Tentative American Standard by the American Society of Mechanical Engineers.

NOTE 2.—Low-carbon seamless tubing rather than medium-carbon should be used for cold bending or fusion welding. The purpose for which pipe is to be used should be stated on the face of the order.

NOTE 3.—The phosphorus limit for the finished pipe is set at 0.06 per cent maximum to permit re-phosphorizing to facilitate welding.

NOTE 4.—A complete description of the American Standard Pipe Thread is contained in the Pipe Thread Standard prepared under the sponsorship of ahe American Gas Association and the American Society of Mechanical Engineers tnd approved as American Standard by the American Engineering Standards Committee.

TENTATIVE SPECIFICATIONS

FOR

COMMERCIAL QUALITY HOT-ROLLED BAR STEELS[1]

Serial Designation: A 107 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered. 1. These specifications cover hot-rolled carbon-steel bars produced in accordance with good mill practice for general commercial purposes. The sections covered are rounds, squares, and hexagons of all sizes, and flats not over 6 in. wide.

Basis of Purchase. 2. The purchaser shall specify each grade desired by its grade designation or by its complete chemical limits.

I. MANUFACTURE

Process. 3. The steel shall be made by the open-hearth or bessemer process, as specified.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 4. The steel shall conform to the requirements as to chemical composition specified in Table I for the respective grades.

Ladle Analyses. 5. (*a*) For bessemer steel a carbon determination shall be made of each melt; and determinations for manganese, phosphorus and sulfur, representing the average of the melts made in each twelve-hour period.

(*b*) For open-hearth steel an analysis of each melt shall be made for carbon, manganese, phosphorus and sulfur.

(*c*) These analyses shall be made by the manufacturer from test ingots taken during the pouring of each melt. The chemical composition thus determined shall conform to the requirements specified, and shall be reported to the purchaser or his representative if requested.

Check Analyses. 6. (*a*) Analyses may be made by the purchaser from finished bars representing each melt of open-hearth steel, and each melt, or

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

TABLE I.—GRADES AND CHEMICAL COMPOSITIONS.

Grades	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent
OPEN-HEARTH GRADES				
Open-Hearth Dead Soft	0.12 max.	0.55 max.	0.04 max.	0.055 max.
Open-Hearth 05 - 15 Carbon	0.05 - 0.15	0.30 - 0.60	0.045 max.	0.055 max
Open-Hearth 10 - 20 Carbon	0.10 - 0.20	0.30 - 0.60	0.045 max.	0.055 max.
Open-Hearth 15 - 25 Carbon	0.15 - 0.25	0.30 - 0.60	0.045 max.	0.055 max.
Open-Hearth 20 - 30 Carbon	0.20 - 0.30	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 25 - 35 Carbon	0.25 - 0.35	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 30 - 40 Carbon	0.30 - 0.40	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 35 - 45 Carbon	0.35 - 0.45	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 40 - 50 Carbon	0.40 - 0.50	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 45 - 55 Carbon	0.45 - 0.55	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 50 - 65 Carbon	0.50 - 0.65	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 55 - 70 Carbon	0.55 - 0.70	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 60 - 75 Carbon	0.60 - 0.75	0.50 - 0.80	0.045 max.	0.055 max.
Open-Hearth 65 - 80 Carbon	0.65 - 0.80			
BESSEMER GRADES				
Bessemer Welding	0.12 max.	0.60 max.	0.11 max.	0.08 max.
Bessemer Soft	0.15 max.	0.70 max.	0.11 max.	....
Bessemer 15 - 25 Carbon	0.15 - 0.25	0.90 max.	0.11 max.	....
Bessemer 25 - 35 Carbon	0.25 - 0.35	0.90 max.	0.11 max.	....
Bessemer 35 - 50 Carbon	0.35 - 0.50	0.90 max.	0.11 max.	....
SCREW STEEL GRADES				
Bessemer Screw	0.08 - 0.16	0.60 - 0.80	0.09 - 0.13	0.075 - 0.15
Open-Hearth Screw	0.15 - 0.25	0.60 - 0.90	0.06 max.	0.075 - 0.15

TABLE II.—PERMISSIBLE VARIATIONS IN THE SIZES OF BARS.

HOT-ROLLED BARS

Rounds, Squares and Hexagons: Sizes Specified	Variations in Size, in.	
	Under	Over
Up to $\frac{1}{2}$ in., inclusive	0.007	0.007
Over $\frac{1}{2}$ to 1 " "	0.010	0.010
" 1 to 2 " "	$\frac{1}{64}$	$\frac{1}{32}$
" 2 to 3 " "	$\frac{1}{32}$	$\frac{3}{64}$
" 3 to 5 " "	$\frac{1}{32}$	$\frac{3}{32}$
" 5 to 8 " "	$\frac{1}{16}$	$\frac{1}{8}$

Flats: Widths Specified	Variations in Width, in.		Variations in Thickness, Under and Over, in., for Thicknesses Specified			
	Under	Over	$\frac{3}{16}$ in. or Under	Over $\frac{3}{16}$ to $\frac{1}{2}$ in., incl.	Over $\frac{1}{2}$ to 1 in., incl.	**Over 1 to 2** in., incl.
Up to 1 in., inclusive	$\frac{1}{64}$	$\frac{1}{32}$	0.006	0.008	0.010	....
Over 1 to 2 " "	$\frac{1}{32}$	$\frac{3}{64}$	0.008	0.012	0.015	$\frac{1}{32}$
" 2 to 4 " "	$\frac{3}{64}$	$\frac{1}{16}$	0.010	0.015	0.020	$\frac{1}{32}$
" 4 to 6 " "	$\frac{1}{16}$	$\frac{3}{32}$	0.010	0.015	0.020	$\frac{1}{32}$

lot of bars, of bessemer steel. The average chemical composition thus determined shall not vary from the limits specified more than 0.03 per cent over or 0.02 per cent under in carbon; 0.03 per cent over or 0.02 per cent under in manganese; 0.005 per cent over in phosphorus; and 0.005 per cent over in sulfur.

(*b*) Samples for analysis shall be taken by machining off the entire cross-section of the bar, or by drilling parallel to the axis of the bar at any point midway between the center and surface.

(*c*) The minimum number of samples to be taken from material representing the same melt or lot, before rejection by the purchaser shall be:

3 for 5 tons or less;
4 for over 5 tons to 10 tons;
5 for over 10 tons to 15 tons;
6 for over 15 tons.

(*d*) In case the number of pieces in a melt is less than the number of samples given, one sample from each piece shall be considered sufficient.

(*e*) Separate determinations shall be made on each sample and the results averaged, unless they clearly indicate mixed grades.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS

Permissible Variations.

7. The variation from the specified diameter, or distance between parallel faces, shall not exceed the limits specified in Table II.

IV. FINISH

Finish.

8. The material shall be free from injurious defects and shall have a workmanlike finish.

V. INSPECTION AND REJECTION

Inspection.

9. The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

10. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples. **Rejection.**

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

11. Samples tested in accordance with Section 6 which represent rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

TENTATIVE SPECIFICATIONS
FOR
COMMERCIAL COLD-FINISHED BAR STEELS AND COLD-FINISHED SHAFTING[1]

Serial Designation: A 108 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered.

1. (*a*) These specifications cover commercial cold-finished bar steels of grades considered to be in common use, including cold-finished bessemer screw stock and cold-finished open-hearth screw stock, also cold-finished shafting.

(*b*) The sections of bar steel covered are rounds, squares and hexagons of all sizes, and flats not over 6 in. wide. The sections of shafting covered are rounds up to 6 in., inclusive.

Basis of Purchase.

2. (*a*) Bars and shafting may be cold-rolled, cold-drawn, turned and polished, or turned and ground.

(*b*) The purchaser shall specify each grade of bar steel desired, by its grade designation or by its complete chemical limits.

(*c*) The steel in bessemer and open-hearth screw stock shall be free-cutting and suitable for high-speed screw machine work, leaving a smooth finish after machining under proper conditions.

(*d*) Cold-finished shafting, when not specified by the purchaser in any particular grade, shall be in such grades as are in accordance with the manufacturer's practice for the respective sizes.

I. MANUFACTURE

Process.

3. (*a*) Bar steel shall be made by the open-hearth or bessemer process, as specified.

(*b*) Shafting shall be made by either or both the following processes: Bessemer or open-hearth.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 4. Bar steel shall conform to the requirements as to chemical composition specified in Tables I and II for the respective grades.

Analysis Reports. 5. An analysis of each melt of open-hearth steel shall be furnished by the manufacturer when requested, showing the percentages of the elements specified, which shall conform to the requirements for the grade specified in Table I.

Check Analyses. 6. (*a*) Analyses may be made by the purchaser from finished bars representing each melt of open-hearth steel, and each melt, or lot of ten tons, of bessemer steel. The chemical composition thus determined shall conform to the requirements in Table I, with the permissible variations in ranges and in maximum limits specified in Table II.

TABLE I.—GRADES AND CHEMICAL COMPOSITIONS FOR COMMERCIAL COLD-FINISHED BAR STEELS.

Grades	Carbon, per cent	Manganese, per cent	Phosphorus, per cent	Sulfur, per cent
OPEN-HEARTH GRADES				
Open-Hearth 05 – 15 Carbon	0.05 – 0.15	0.30 – 0.60	0.045 max.	0.05 max.
Open-Hearth 10 – 20 Carbon	0.10 – 0.20	0.30 – 0.60	0.045 max.	0.05 max.
Open-Hearth 15 – 25 Carbon	0.15 – 0.25	0.30 – 0.60	0.045 max.	0.05 max.
Open-Hearth 20 – 30 Carbon	0.20 – 0.30	0.50 – 0.80	0.045 max.	0.05 max.
Open-Hearth 25 – 35 Carbon	0.25 – 0.35	0.50 – 0.80	0.045 max.	0.05 max.
Open-Hearth 30 – 40 Carbon	0.30 – 0.40	0.50 – 0.80	0.045 max.	0.05 max.
Open-Hearth 35 – 45 Carbon	0.35 – 0.45	0.50 – 0.80	0.045 max.	0.05 max.
Open-Hearth 40 – 50 Carbon	0.40 – 0.50	0.50 – 0.80	0.045 max.	0.05 max.
BESSEMER GRADES				
Bessemer Soft	0.15 max.	0.60 max.	0.11 max.	....
SCREW-STEEL GRADES				
Bessemer Screw	0.08 – 0.16	0.60 – 0.80	0.09 – 0.13	0.075 – 0.15
Open-Hearth Screw	0.15 – 0.25	0.60 – 0.90	0.06 max.	0.075 – 0.15

(*b*) Samples for analysis shall be taken by machining off the entire cross-section of the bar, or by drilling parallel to the axis of the bar at any point midway between the center and surface.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS

Permissible Variations. 7. The variation from the specified diameter, or distance between parallel faces, shall not exceed the limits specified in Tables III and IV.

IV. FINISH

Finish. 8. The material shall be free from injurious defects and shall have a bright smooth surface.

TABLE II.—VARIATIONS IN RANGES AND IN MAXIMUM LIMITS SPECIFIED IN TABLE I PERMITTED ON CHECK ANALYSIS. (Open-hearth and bessemer screw stock not included.)

Grades	Permissible Variations from Limits Specified in Table I					
	Carbon		Manganese		Phosphorus	Sulfur
	Under Lower Limit	Over Upper Limit	Under Lower Limit	Over Upper Limit	Over Maximum	Over Maximum
OPEN-HEARTH GRADES						
Open-Hearth 05 - 15 Carbon	......	0.03	0.05	0.05	0.01	0.01
Open-Hearth 10 - 20 and 12 - 25 Carbon	0.02	0.04	0.05	0.05	0.01	0.01
Open-Hearth 20 - 30 and 25 - 35 Carbon	0.03	0.05	0.05	0.10	0.01	0.01
Open-Hearth 30 - 40 and 35 - 45 Carbon	0.03	0.06	0.05	0.10	0.01	0.01
Open-Hearth 40 - 50 Carbon	0.03	0.07	0.05	0.10	0.01	0.01
BESSEMER GRADES						
Bessemer Soft	......	0.03	......	0.05	0.02	......

TABLE III.—PERMISSIBLE VARIATIONS IN THE SIZES OF COLD-FINISHED BARS

Sizes Specified	Variations in Size, in.					
	Rounds and Hexagons		Squares		Flats, Width and Thickness	
	Under	Over	Under	Over	Under	Over
Up to 0.3 in., inclusive	0.002	0	0.0025	0.0025	0.003	0.003
Over 0.3 to 1 " "	0.003	0	0.0025	0.0025	0.003	0.003
" 1 to 2½ " "	0.004	0	0.004	0.004	0.004	0.004
" 2½ in.	0.005	0	0.005	0.005	0.005	0.005

TABLE IV.—PERMISSIBLE VARIATIONS IN THE SIZES OF COLD-FINISHED SHAFTING

Diameters Specified	Variations in Dimensions, in.	
	Under	Over
ROUND SHAFTING		
Up to 1 in., inclusive	0.002	0
1 1/16 to 2 " "	0.003	0
2 1/16 to 4 " "	0.004	0
4 1/16 to 6 "	0.005	0

V. INSPECTION AND REJECTION

9. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. **Inspection.**

10. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 6 shall be reported within five working days from the receipt of samples. **Rejection.**

(*b*) Material which shows injurious defects subsequent to acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

11. Samples tested in accordance with Section 6 which represent rejected material shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time. **Rehearing.**

TENTATIVE SPECIFICATIONS
FOR
COLD-ROLLED STRIP STEEL[1]

Serial Designation: A 109 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered.

1. These specifications cover five grades of commercial cold-rolled strip steel as follows:

Grade No. 1, or "Hard" Temper;
Grade No. 2, or "Half Hard" Temper;
Grade No. 3, or "Quarter Hard" Temper;
Grade No. 4, or "Planished" Temper;
Grade No. 5, or "Dead Soft" Temper.

Selection of Temper.

2. (*a*) These five grades of cold-rolled strip steel are commonly used for blanking, bending, forming, spinning and deep drawing.

(*b*) It should be understood, however, that the tempers and uses given are general. It is recommended that the purchaser furnish the manufacturer with a sample or sketch of the article to be made.

I. MANUFACTURE

Process.

3. The steel shall be made by the open-hearth process for temper Nos. 3, 4 and 5.

II. CHEMICAL REQUIREMENTS

Chemical Composition.

4. The steel shall conform to the following requirements as to chemical composition:

TEMPER NOS. 3, 4 AND 5		
Carbon	0.05 to 0.15	per cent
Manganese	0.20 to 0.50	"
Phosphorus	not over 0.04	"
Sulfur	not over 0.055	"

TEMPER NOS. 1 AND 2	
Carbon	not over 0.25 per cent

5. Samples for analysis shall be taken by machining the entire cross-section of the strip.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

III. PHYSICAL PROPERTIES AND TESTS

Tension Tests.

6. The material shall conform to the following requirements as to tensile properties:

	No. 1, Hard	No. 2, Half Hard		No. 3, Quarter Hard		No. 4, Planished	No. 5, Dead Soft
Tensile strength, minimum, lb. per sq. in...	60 000	55 000		45 000		40 000	40 000
		Min.	Max.	Min.	Max.	Min.	Min.
Elongation in 2 in., per cent:							
Below 0 062 in.............		5	15.0	15.0	30.0	30.0	32.5
" 0.125 to 0.062 in. incl...		5	16.0	16.0	32.5	32.5	33.5
" 0.187 to 0.125 in. " ...		5	17.5	17.5	33.5	33.5	36.0
" 0.250 to 0.187 in. " ...		5	19.0	19.0	36.0	36.0	38.5
0.250 in. or over in thickness.		5	20.0	20.0	38.5	38.5	40.0

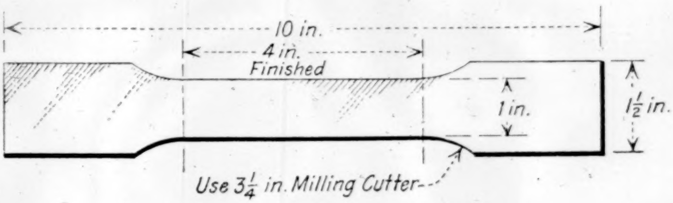

FIG. 1.—Tension Test Specimen.

Bend Tests.

7. The bend test specimens shall stand being bent cold as specified below without cracking on the outside of the bent portion:

No. 1, Hard	No. 2, Half Hard	No. 3, Quarter Hard	No. 4, Planished	No. 5, Dead Soft
Shall not be required to make bends in either direction of grain.	Shall bend to a sharp right angle across the grain.	Shall bend flat on itself across the grain and to a sharp right angle along the grain.	Shall bend flat upon itself both ways of the grain.	Shall bend flat upon itself both ways of the grain.

NOTE.—To bend across the grain means that the axis of the bend shall be at right angles to the direction of rolling.

To bend with the grain means that the axis of the bend shall be parallel to the direction of rolling.

Test Specimens.

8. (*a*) The tension test specimens shall be cut in both a longitudinal and transverse direction from the strip except in the case of widths narrower than 10 in., in which case only longitudinal specimens shall be taken. The specimen shall be machined to the form and dimensions shown in Fig. 1.

NOTE.—The form of test specimen shown in Fig. 1 will be modified to agree with whatever form of test specimen is standardized for thin sheet metals by Committee E-1 on Methods of Testing. Also, the physical properties given in Section 6 may be modified later to agree with results obtained with a standardized form of test specimen.

(*b*) The test specimens shall be marked off for every 1-in. length within the 4-in. gage length. The percentage of elongation in 2 in. shall be determined by averaging the increase in length of the two 2-in. lengths that include the break.

(*c*) Bend test specimens may have the edges rounded.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS

Thickness. 9. The thickness of the strip measured at a point $\frac{1}{2}$ in. from the edge shall not vary from the thickness specified by more than the following plus or minus variations in inches:

Thickness, in	Width							
	Up to 2 in., inclusive	Over 2 to 4 in., inclusive	Over 4 to 6 in., inclusive	Over 6 to 8 in., inclusive	Over 8 to 12 in., inclusive	Over 12 to 16 in., inclusive	Over 16 to 24 in., inclusive	Over 24 in.
0.200 or over........	0.003	0.004	0.005	0.005	0.006	0.006	0.007	0.008
Below 0.200 to 0.100......	0.002	0.003	0.004	0.004	0.005	0.005	0.006	0.007
" 0.100 to 0.050......	0.002	0.002	0.003	0.003	0.004	0.004	0.005	0.006
" 0.050 to 0.035......	0.002	0.002	0.002	0.002	0.003	0.003	0.004	
" 0.035 to 0.015......	0.0015	0.002	0.002	0.002	0.002			
" 0.015 to 0.010......	0.001	0.0015	0.0015	0.0015	0.0015			
" 0.010 to 0.006	0.00075	0.001	0.001					
" 0.006..............	0.0005	0.0005	0.0005					

Width. 10. The width of the strip shall not vary from that specified by more than the following amounts:

MILL EDGE STEEL

	PLUS	MINUS
Up to 6 in. inclusive..................	$\frac{1}{16}$ in.	$\frac{1}{16}$ in.
Over 6 to 10 in......................	$\frac{3}{32}$ in.	$\frac{3}{32}$ in.
Over 10 to 16 in....................	$\frac{5}{32}$ in.	$\frac{5}{32}$ in.
Over 16 in..........................	$\frac{1}{4}$ in.	$\frac{1}{4}$ in.

SLIT, SHEARED OR FILE EDGE STEEL

	PLUS	MINUS
Up to 0.100 in......................	0.015 in.	0.015 in.
0.100 to 0.200 "	0.025 in.	0.020 in.
0.200 to 0.300 "	0.035 in.	0.025 in.
0.300 to 0.400 "	$\frac{1}{16}$ in.	$\frac{1}{16}$ in.
0.400 to 0.500 "	$\frac{1}{8}$ in.	$\frac{1}{8}$ in.

ROUND OR SQUARE-ROLLED EDGE STEEL

WIDTH, IN.	THICKNESS, IN.	TOLERANCES IN WIDTH, PLUS OR MINUS, IN.
$\frac{1}{2}$ and narrower...............	$\frac{3}{16}$ and thinner	$\frac{1}{64}$
Over $\frac{1}{2}$ to 1 incl................	$\frac{3}{16}$ to 0.025 incl.	$\frac{1}{32}$
" 1 to 2	$\frac{1}{4}$ to 0.025 "	$\frac{1}{32}$
" 2 to 4	$\frac{1}{4}$ to 0.035 "	$\frac{3}{64}$
" 4 to 6	$\frac{1}{4}$ to 0.047 "	$\frac{3}{64}$

Strip wider than 6 in. is not furnished.

Length. 11. (*a*) Cold-rolled strip shall be furnished in 8-ft. lengths and ends unless otherwise specified. When so furnished the allowance shall be plus 3 in. with no negative allowance.

(*b*) When a definite length in inches is specified, the permissible variation shall be plus 1 in. with no negative allowance. Cutting to definite lengths over 36 in. does not relieve the buyer from scrap loss and short lengths will be included, cut to multiples, if so desired.

Straightness. 12. The standard for straightness shall be $\frac{1}{2}$ in. bow in 8 ft.

Flatness. 13. When flatness is an essential to the purchaser, it should be so specified. Flatness shall be determined by placing the strips in 8-ft. lengths on a flat surface, when no part of the strip shall rise more than $\frac{1}{4}$ in. from the surface.

V. FINISH

Finish. 14. Cold-rolled strip steel shall have a bright, smooth surface and shall be free from injurious defects.

Inspection. 15. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture may be made prior to shipment, and such inspection shall be final.

16. In case material is not inspected at the place of manufacture, the purchaser may make the tests to govern the acceptance or rejection of the material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

17. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 18. Unless otherwise specified, any rejections based on tests made in accordance with Section 16 shall be reported within ten working days from the receipt of samples.

19. Material which shows injurious defects while being finished by the purchaser will be rejected, and the manufacturer shall be notified within 90 days from the date of the receipt of the material by the purchaser.

Rehearing. 20. Samples tested in accordance with Section 16, which represent rejected material, shall be preserved for one month from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

TENTATIVE SPECIFICATIONS
FOR THE
COATING ON ZINC-COATED (GALVANIZED) WIRE[1]

Serial Designation: A 110 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope

1. These specifications cover zinc coatings applied by the hot-dip and electro-deposition methods to iron or steel wire, and are intended to apply only to the particular wire products covered by the following specifications of the American Society for Testing Materials:[2]

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire (Serial Designation: A 111 – 26 T);[3]

Tentative Specifications for Zinc-Coated (Galvanized) Iron or Steel Tie Wires (Serial Designation: A 112 – 26 T).[4]

I. MATERIAL

Zinc.

2. The zinc used for the coating shall be of any grade of zinc conforming to the requirements of the Standard Specifications for Spelter (Serial Designation: B 6) of the American Society for Testing Materials.[5]

II. WEIGHT OF COATING

Weight of Coating.

3. There shall be four classes of zinc coating, which represent the usual commercial weights of zinc coating applied to wire and wire products. For special commodities other classes of zinc coatings may be defined. The four usual commercial classes of zinc coatings are as follows:

Class A.—The minimum weight of the coating for this class shall be 0.8 oz. per sq. ft. of surface of the stripped wire, and the coating shall withstand a minimum of four 1-minute dips by the Preece test.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] This list of specifications will be added to as the specifications for specific wire products are prepared.

[3] See p. 667.

[4] See p. 672.

[5] 1924 Book of A.S.T.M. Standards.

Class B.—The weight of the coating for this class shall be from 0.60 to 0.79 oz. per sq. ft. of surface of the stripped wire and shall withstand a minimum of three 1-minute dips by the Preece test.

Class C.—The weight of the coating for this class shall be from 0.40 to 0.59 oz. per sq. ft. of surface of the stripped wire and shall withstand a minimum of two 1-minute dips by the Preece test.

Class D.—The weight of the coating for this class shall be from 0.10 to 0.39 oz. per sq. ft. of surface of the stripped wire and shall withstand a minimum of one 1-minute dip by the Preece test.

III. METHOD OF TESTING WEIGHT OF COATING

4. The coating shall be tested for quantity or weight of coating in a stripping test and for uniformity by the Preece test.

5. (*a*) The stripping test for the weight of coating shall be conducted in accordance with the Hydrochloric Acid - Antimony Chloride Method, as described in the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (Serial Designation: A 90) of the American Society for Testing Materials.[1]

(*b*) The test for uniformity of coating shall be conducted in accordance with the requirements for the Preece test described in the appendix to the Standard Methods of Determining Weight of Coating on Zinc-Coated Articles (Serial Designation: A 90) of the American Society for Testing Materials.[1]

IV. PHYSICAL PROPERTIES

6. When a wrap test is specified, the zinc coating shall adhere firmly to the wire when the zinc-coated wire is wrapped in a closed helix at the rate of about 15 turns per minute, two wraps around a cylindrical mandrel of the diameter specified in the individual specification for the particular wire product covered.

An adherent coating shall be one that cannot be removed from the wire after wrapping by rubbing with the bare fingers.

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[1] 1924 Book of A.S.T.M. Standards.

EXPLANATORY NOTES

1. The weight of the coating of any class of wire being found on inspection to be heavier than that defined for the class shall not constitute cause for rejection unless otherwise specified on the purchase order. The purchaser of these products being interested in the protection afforded by the coating should not ordinarily take exception to securing greater protection than anticipated.

2. For wire to be fabricated after galvanizing, it is considered desirable that the galvanized wire shall withstand winding on a relatively small mandrel without cracking of the coating. However, it is not the sense of these specifications to encourage the production of flexible and adherent coatings by reduction of their thickness, or to go on record as stating that the protective value of zinc coatings per unit of thickness is or is not influenced by the flexibility of the coating.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED (GALVANIZED) IRON OR STEEL TELEPHONE AND TELEGRAPH LINE WIRE[1]

Serial Designation: A 111 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

1. These specifications cover galvanized iron or steel wire for use in telephone and telegraph transmission. **Scope.**

I. MANUFACTURE

2. The material shall be mild homogeneous iron or steel of such quality and purity that, when drawn and uniformly annealed, the finished wire will have the properties and characteristics herein specified.

II. PROPERTIES AND TESTS OF COATING

3. The weight and uniformity of the coating shall be determined in accordance with the requirements of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire (Serial Designation: A 110 - 26 T) of the American Society for Testing Materials.[2]

(*A*) *Treatment of Samples*

4. Samples shall have a length of about 10 in., and shall be tagged or marked to correspond with the coils from which they were cut.

(*B*) *Weight of Coating*

5. The weight of the coating of wires having a nominal diameter of 0.134 in. and smaller shall conform to Class A (minimum 0.80 oz. per sq. ft.) of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire (Serial Designation: A 110 - 26 T) of the American Society for Testing Materials[2] while wires having a nominal

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 664.

diameter greater than 0.134 in. shall conform to Class A of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire, except that the minimum weight of the coating shall not be less than 1 oz. per sq. ft. of the surface of the stripped wire.

(C) *Uniformity of Coating*

6. The uniformity of the coating shall conform to Class A of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire, except that in the case of wire 0.100 in. or smaller in diameter the time of the fourth immersion shall be reduced to $\frac{1}{2}$ minute.

III. PHYSICAL PROPERTIES AND TESTS

(A) *Mechanical Test of Coating*[1]

(B) *Mechanical Test of Wire*

7. The tensile strength of the zinc-coated iron or steel wire shall conform to the values given in Table I:

Table I.—Minimum Tensile Strengths, lb.

Diameter, in.	Size, B. W. G.	Less Than 5000 Mile-Ohm Resistivity	5000–5700 Mile-Ohm Resistivity	Over 5700 Mile-Ohm Resistivity
0.238	4	2028	2270	2433
0.203	6	1475	1650	1770
0.165	8	975	1090	1170
0.148	9	785	880	942
0.134	10	645	720	774
0.120	11	515	575	618
0.109	12	425	475	510
0.083	14	247	275	297

8. The elongation shall be not less than 10 per cent in 10 in.

9. The wire shall be capable of withstanding not less than 35 twists in a length equivalent to 100 diameters.

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[1] If specified by the purchaser the zinc coating shall conform to the wrapping test prescribed in Section 6 of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire (Serial Designation: A 110 – 26 T) of the American Society for Testing Materials (see p. 664). The type of coating desired as described below shall be as specified:

1. A zinc-coated wire of which 100 per cent of the samples tested will wrap, without failure, on a mandrel of a diameter equal to that of the wire.
2. A zinc-coated wire of which 100 per cent of the samples tested will wrap, without failure, on a mandrel of a diameter equal to five times that of the wire.
3. A zinc-coated wire of which 100 per cent of the samples tested will wrap, without failure, on a mandrel of a diameter equal to twelve times that of the wire.

(C) *Electrical Tests*

10. The resistivity of the wire expressed in pounds per mile-ohm (product of resistance in ohms per mile and the weight in pounds per mile), at 20° C. (68° F.) shall conform to the requirements given in Table II.

TABLE II.

	Resistivity, Mile-Ohm		
	Less Than 5000 Mile-Ohm	5000–5700 Mile-Ohm	Over 5700 Mile-Ohm
Nominal average	4750	5350	6000
Maximum of any sample	5000	5700	7000

IV. PERMISSIBLE VARIATIONS

11. (*a*) The size of the finished wire shall be expressed as the diameter of the wire in decimal fractions of an inch.

(*b*) The permissible variations from nominal diameter shall be:

For wire 0.109 in. or over in diameter	±0.004 in.
For wire under 0.109 in. in diameter	±0.003 in.

(*c*) Each coil shall be gaged in three places; one near each end, and one approximately at the middle.

(*d*) A coil shall be rejected if the average gage is not within the limits specified in Paragraph (*b*).

V. WORKMANSHIP AND FINISH

12. (*a*) The wire shall be free from splints, scales, inequalities, flaws and other imperfections not consistent with good commercial practice.

(*b*) To insure the removal of defective ends from the wire, the supplier shall cut off as much as may be necessary from the ends of each coil.

13. The zinc coating shall be smooth and continuous.

VI. PACKING AND MARKING

14. (*a*) The finished wire shall be furnished in compact coils reasonably symmetrical in shape. The diameter of the eye of each coil shall be not less than 20 in. nor more than 22 in. except in case of wire of 0.203 or larger, the maximum diameter of eye may be 24 in.

(*b*) Each coil of wire, 0.134 in. or under in diameter, shall consist of one continuous piece, without joints. Each coil of wire 0.148 in. or over in diameter shall consist of one continuous piece, except that not more than 10 per cent of the coils in any lot offered for inspection may contain one joint per coil, provided the joint is made in accordance with the sketch shown on Fig. 1 and galvanized after the joint is made.

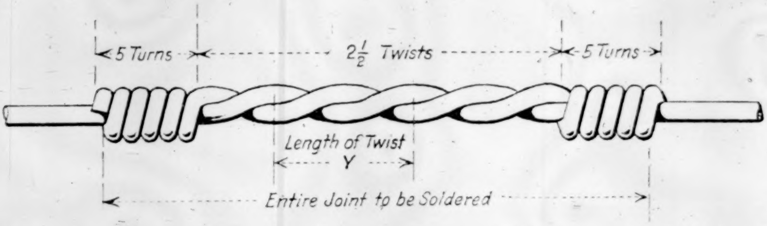

FIG. 1.—Standard Western Union Iron Wire Joint.

DIAMETER, IN.	SIZE, B. W. G.	DISTANCE "Y"
0.238	4	1¾ in.
0.203	6	1½ in.
0.165	8	1¼ in.
0.148	9	1 in.
0.134	10	1 in.
0.120	11	¾ in.
0.109	12	¾ in.
0.083	14	⅝ in.

(*c*) The length of wire in each coil shall conform to the values given in Table III. The weight of any coil shall not vary by more than 10 per cent from the specified weights.

TABLE III.

DIAMETER, IN.	SIZE, B. W. G.	LENGTH OF WIRE IN COIL
0.238	4	¼ mile or 197 lb.
0.203	6	⅓ mile or 191 lb.
0.165	8	½ mile or 189 lb.
0.148	9	½ mile or 152 lb.
0.134	10	½ mile or 126 lb.
0.120	11	½ mile or 100 lb.
0.109	12	½ mile or 82 lb.
0.083	14	½ mile or 48 lb.

15. Each coil shall be securely bound in four separate places, equally spaced, with at least two wrappings of galvanized iron wire, the binding wire to be not smaller than 0.109 in. in diameter. The outer end of each coil shall be bent back over the binding wire to prevent it from crowding into the coil. To each coil shall be securely wired a metal tag showing the size and kind of wire, the weight of the coil and the manufacturer's name.

VII. INSPECTION AND REJECTION

16. The supplier shall afford the inspector representing the purchaser, without charge, suitable facilities and equipment for making the tests required by these specifications, in order that he may satisfy himself that the material is being furnished in accordance with these specifications.

17. The inspector shall visually examine the entire shipment or lot of coils for surface imperfections. If, after testing as described below, over 3 per cent of the coils in the entire lot are found defective, the purchaser may reject the entire lot. One-third of the coils shall be examined to determine whether the diameter is within the specified limits. If over 3 per cent of these coils do not conform to the requirements for the diameter, the purchaser may reject the entire lot. The inspector shall select at random during the visual inspection one sample coil from every 10 in the lot but not less than 3 from the entire lot. One sample of suitable length shall be cut from each coil selected for use in making the chemical and physical tests of the coating and wire above described. If more than 3 per cent of the samples selected for test, in no case less than three samples, fail to pass any of these tests, the purchaser may reject the entire lot. If not more than 3 per cent of the samples fail, a second set of samples, consisting of 2 specimens from each of the coils from which the original non-conforming samples were taken, shall be cut and tested for the non-conforming properties. If any of these samples fail, the purchaser may reject the entire lot.

TENTATIVE SPECIFICATIONS
FOR
ZINC-COATED (GALVANIZED) IRON OR STEEL TIE WIRES[1]

Serial Designation: A 112 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope 1. These specifications cover galvanized iron or steel tie wires for use in tying galvanized iron or steel telephone and telegraph line wire to insulators.

I. MANUFACTURE

2. The tie wires shall be cut from a soft grade of zinc-coated iron or steel wire which shall have the properties and characteristics herein specified.

II. PROPERTIES AND TESTS OF COATING

3. The weight and uniformity of the coating shall be determined as specified in the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire (Serial Designation: A 110 - 26 T) of the American Society for Testing Materials.[2]

(A) *Treatment of Samples*

4. Sample tie wires shall be tagged or marked to correspond with the bundles from which they were taken.

(B) *Weight of Coating*

5. The weight of the coating of wires having a nominal diameter of 0.134 in. and smaller shall conform to Class A (minimum 0.80 oz. per sq. ft.) of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire (Serial Designation: A 110 - 26 T) of the American Society for Testing Materials,[2] while wires having a nominal diameter greater than 0.134 in. shall conform to Class A of the Tenta-

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. James Aston, Secretary of Committee A-5 on Corrosion of Iron and Steel, Department of Mining and Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.

[2] See p. 664.

tive Specifications for the Coating on Zinc-Coated (Galvanized) Wire except that the minimum weight of the coating shall not be less than 1 oz. per sq. ft. of the surface of the stripped wire.

(C) *Uniformity of Coating*

6. The uniformity of the coating shall conform to Class A of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire except that in the case of wire 0.100 in. to 0.083 or smaller in diameter the time of the fourth immersion shall be reduced to $\frac{1}{2}$ minute.

III. PHYSICAL PROPERTIES AND TESTS

(A) *Mechanical Test of Coating*[1]

(B) *Mechanical Test of Wire*

7. The average tensile strength of all test samples shall not exceed 57,000 lb. per sq. in. and the tensile strength of individual test samples shall not exceed 60,000 lb. per sq. in.

8. The finished tie wire shall have an elongation not less than 12 per cent in 10 in.

IV. DIMENSIONS

9. The diameters of the respective sizes of tie wires shall be 0.165, 0.148, 0.134, 0.109 and 0.083 in.

V. PERMISSIBLE VARIATIONS

10. (*a*) The size of the finished wire shall be expressed as the diameter of the wire in decimal fractions of an inch.

(*b*) The permissible variation from nominal diameter shall be:

For wire 0.109 in. or over in diameter...........	±0.004 in.
For wire under 0.109 in. in diameter............	±0.003 in.

(*c*) Three tie wires from each test bundle as defined in Section 18 shall be gaged in at least three separate places.

(*d*) The bundle will be rejected if the average gage is not within the limits specified in Paragraph (*b*).

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[1] If specified by the purchaser the coating shall conform to the wrapping test described in Section 6 of the Tentative Specifications for the Coating on Zinc-Coated (Galvanized) Wire (Serial Designation: A 110 – 26 T) of the American Society for Testing Materials (see p. 664). The type of coating desired, as described below, shall be as specified:

1. A zinc-coated wire of which 100 per cent of the samples tested will wrap, without failure, on a mandrel of a diameter equal to that of the wire.
2. A zinc-coated wire of which 100 per cent of the samples tested will wrap, without failure, on a mandrel of a diameter equal to five times that of the wire.
3. A zinc-coated wire of which 100 per cent of the samples tested will wrap, without failure, on a mandrel of a diameter equal to twelve times that of the wire.

11. The length of the tie wires shall not vary by more than $\frac{1}{8}$ in. over or under the specified length.

VI. WORKMANSHIP AND FINISH

12. The wire shall be free from splints, scales, inequalities, flaws, and other imperfections not consistent with good commercial practice.

13. The zinc coating shall be smooth and continuous.

VII. PACKING AND MARKING

14. Bundles of iron or steel tie wires shall be packed as specified but in no case shall exceed 50 lb.

15. Each bundle shall be bound at the middle with galvanized iron wire and then wrapped with burlap or heavy paper and bound near each end with the same kind of wire used for the inner binding.

16. To each bundle shall be securely fastened a strong tag showing the size of the tie wire, gross weight and the supplier's name.

VIII. INSPECTION AND REJECTION

17. The supplier shall afford the inspector representing the purchaser, without charge, suitable facilities and equipment for making the tests required by these specifications, in order that he may satisfy himself that the material is being furnished in accordance with these specifications.

18. The inspector shall visually examine the entire shipment or lot of bundles for surface imperfections. If after testing as described below, over 3 per cent of the bundles in the entire lot are found defective, the purchaser may reject the entire lot. One-third of the bundles are to be examined to determine whether the diameter is within the specified limits. If over 3 per cent of these bundles do not conform to the requirements for the diameter, the purchaser may reject the entire lot. The inspector shall select at random during the visual inspection one sample bundle from every 10 in the lot but not less than 3 from the entire lot. One sample of suitable length shall be cut from each bundle selected for use in making the chemical and physical tests of the coating and wire above described. If more than 3 per cent of the samples selected for test, in no case less than 3 samples, fail to pass any of these tests, the purchaser may reject the entire lot. If not more than 3 per cent of the samples fail, a second set of samples, consisting of 2 specimens from each of the bundles from which the original non-conforming samples were taken, shall be cut and tested for the non-conforming properties. If any of these samples fail, the purchaser may reject the entire lot.

TENTATIVE METHODS OF TEST
FOR
MAGNETIC PROPERTIES OF IRON AND STEEL[1]

Serial Designation: A 34 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

A. Normal Induction and Hysteresis

I. DEFINITIONS

Definitions.

1. (*a*) *Normal Induction.*—The induction, produced under a given magnetizing force, in a substance which has been previously demagnetized and then subjected to a sufficient number of reversals of the given magnetizing force to bring it to a cyclic condition.

Both the induction and magnetizing force shall be expressed in terms of the c.g.s. electromagnetic units (gauss and gilbert per centimeter respectively).

(*b*) *Magnetic Permeability.*—The ratio of the normal induction to the magnetizing force which produces it. Thus:

$$\text{Permeability} = \frac{\text{Gausses}}{\text{Gilberts per centimeter}}$$

(*c*) *Residual Induction.*—The magnetic induction which exists in a substance after the magnetizing force has been reduced to zero.

Note.—If the induction has been reduced from a point on the normal induction curve it is called the normal residual induction.

(*d*) *Coercive Force.*—The negative value of magnetizing force required to reduce the induction in a substance to zero.

Note.—If the induction has been reduced to zero from a point on the normal induction curve the coercive force is called the normal coercive force.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

These Tentative Methods, when adopted as standard, will supersede the present Standard Methods of Test for Magnetic Properties of Iron and Steel (Serial Designation: A 34 - 24), 1924 Book of A.S.T.M. Standards.

II. TEST SPECIMENS

Test Specimens.

2. (*a*) Test specimens may consist of rings, straight bars or strips of uniform cross-section.

(*b*) Ring specimens shall be continuous, having no joints or welds. The ratio of mean diameter to radial width shall be not less than 10.

(*c*) Sharp shears or dies shall be used in the preparation of specimens of sheet material. If the radial width of ring specimens or the width of straight strips of sheet material is less than 3 cm. ($1\frac{3}{16}$ in.), the punching or cutting strains shall be removed before testing by an annealing process acceptable to both manufacturer and purchaser.

(*d*) Test specimens of sheet material consisting of straight strips shall be cut half parallel and half at right angles to the direction of rolling, and in types of test requiring companion samples each half shall contain an equal number of each kind of strips.

Size of Specimen.

3. (*a*) Test specimens of sheet material shall have a cross-sectional area of not less than 2 sq. cm. (0.31 sq. in.) nor more than 4 sq. cm. (0.62 sq. in.) and shall be so selected from not less than two sheets that their properties shall represent as nearly as practicable the average properties of the sheets. (See Figs. 1 and 2.)

(*b*) The cross-section of specimens of sheet material shall be calculated from measured values of length and mass and measured or assumed values of density.

(*c*) For silicon steels, a density of 7.7 g. per cu. cm. shall be assumed if the silicon content is 2 per cent or less and a density of 7.5 g. per cu. cm. shall be assumed if the silicon content is over 2 per cent.[1]

(*d*) For nickel-iron alloys the density shall be assumed from the nickel content as given by the straight lines joining the points defined as follows:[2]

NICKEL, PER CENT	DENSITY, G. PER CU. CM.
0	7.85
30	8.00
100	8.90

(*e*) For other alloys, a density corresponding to the actual measured or estimated value shall be used.

4. Specimens of magnet steel shall be hardened previous to testing in accordance with a procedure acceptable to both manufacturer and purchaser.

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[1] For silicon steel having a 2-per-cent silicon content the electrical resistance is 2.6 ohms per meter gram.

[2] For 50-per-cent nickel content the density is 8.26 g. per cu. cm. For 80-per-cent nickel content the density is 8.64 g. per cu. cm.

III. STANDARD DATA

Standard Data.

5. (*a*) The standard normal-induction data for all magnetic materials shall consist of corresponding values of normal induction and magnetizing force at suitable intervals within the range of values agreed upon by the manufacturer and purchaser.

(*b*) Residual-induction and coercive-force values for transformer core material and material of the type used for electromagnet cores shall be determined from a maximum normal induction of 10,000 gausses.

(*c*) For permanent magnet steel, the residual induction and coercive force shall be determined from the maximum normal induction corresponding to a magnetizing force of 200 gilberts per cm. unless the maximum permeability is less than 100, in which case the maximum magnetizing force shall be not less than $2\frac{1}{2}$ times the value of the magnetizing force at which this maximum permeability occurs and shall be some multiple of 200.

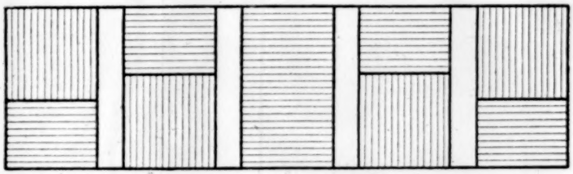

FIG. 1.

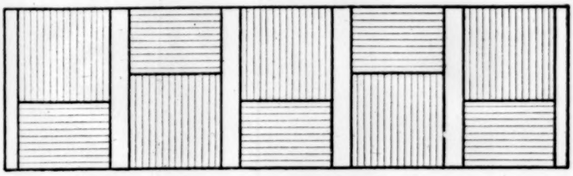

FIG. 2.

IV. METHODS OF TEST

Apparatus.

6. The tests may be made by means of one of the following methods:

The Rowland Ring Method.—This method may be used for any material and any magnetizing forces.

The Burrows Compensated Double Yoke.—This type of apparatus is suitable for tests at magnetizing forces up to 300 gilberts per cm. For higher magnetizing forces, serious difficulty due to heating may be encountered unless special temperature control is provided.

The magnetizing coils shall be not less than 20 cm. ($7\frac{7}{8}$ in.) in length and the ratio of the area of the test coil to that of the specimen shall be such that the air correction factor shall be not greater than 5. This air correction may be applied by calculation or eliminated by means of an adjustable mutual inductance, having its primary in series with the main permeameter magnetizing winding and its secondary in series with the main test coil. This mutual inductance shall be set to such a value that the flux in the space between the sample and the test coil shall be automatically compensated for. If desired, the two main magnetizing coils may be connected in series and the average values for the whole sample[1] determined by connecting the two middle test coils in series and using them as one. In this arrangement, four auxiliary test coils near the ends of the specimens are connected in series and used as one coil for adjusting the current in the compensating magnetizing coils.

The Fahy Simplex Permeameter.—This type of apparatus is suitable for tests at magnetizing forces up to 300 gilberts per cm. without difficulties due to heating. For higher values of magnetizing force, the high magnetization adapter may be used.

Isthmus Method.—This method, as described in U. S. Bureau of Standards *Scientific Papers Nos. 361* and *383,* is suitable for tests at magnetizing forces exceeding 200 gilberts per cm.

V. ACCURACY

Accuracy.

7. (*a*) The accuracy of the results of magnetic tests depends not only upon the method or apparatus used but also upon the nature of the specimen. The most common sources of error are (1) lack of uniformity in permeability along the length of the specimen, (2) mechanical strain, and (3) temperature variations. Errors due to these causes are indeterminate and may be large.

(*b*) For specimens having a satisfactory degree of uniformity, clamped so as to be free from mechanical strain and kept at a constant temperature within 5° C., the methods specified above may be expected to give the following accuracy: For normal induction, the values of magnetizing force corresponding to inductions up to an induction equal to two-thirds of that corresponding to the maximum magnetizing force specified in Section 5 (*c*) should be accurate within 3 per cent, provided the permeability does not exceed 10,000. This permeability limitation does not apply to the ring method. Values of induction greater than the above should be accurate within 1 per cent. For residual induction, values should be accurate within 2 per cent and for coercive force within 5 per cent.

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[1] The limits of cross-sectional area given in Section 3 (*a*) shall apply to each half of the whole sample.

B. Core Loss

VI. DEFINITIONS

Definitions.

8. (*a*) *Core Loss.*—The power consumption in electrical sheet steel when subjected to an alternating magnetization.

(*b*) *Standard Core Loss.*—The total power in watts consumed in each kilogram of material at a temperature of 25° C. when subjected to a harmonically varying induction having a maximum of 10,000 gausses and a frequency of 60 cycles per second, when determined in accordance with definite prescribed methods. It is represented by the symbol $W_{10/60}$.

(*c*) *Aging Coefficient.*—The percentage change in the standard core loss after continued heating at 100° C. for 600 hours.

VII. PROCEDURE

Conditions of Testing.

9. The standard core loss shall be measured under the following conditions:

(*a*) The magnetic circuit shall consist of 10 kg. (22 lb.) of the test material, cut with a sharp shear into strips 50 cm. ($19\frac{11}{16}$ in.) in length and 3 cm. ($1\frac{3}{16}$ in.) in width, one-half parallel and one-half at right-angles to the direction of rolling, made up into four equal bundles, two containing material parallel and two containing material at right angles to the direction of rolling, and finally built into the four sides of a square with butt joints and opposite sides consisting of material cut in the same manner. No insulation other than the natural scale of the material (except in the case of scale-free material) shall be used between laminations, but the corner joints may be separated by tough paper 0.1 mm. (0.004 in.) in thickness.

(*b*) The magnetizing winding shall consist of four solenoids surrounding the four sides of the magnetic circuit and joined in series. A secondary coil shall be used for energizing the voltmeter and the potential coil of the wattmeter.

These solenoids shall be wound on a form of any non-magnetic non-conducting material of the following dimensions:

Inside cross-section	4 by 4 cm.
Thickness of wall	not over 0.3 cm.
Winding length	42 cm.

The primary winding on each solenoid shall consist of 150 turns of copper wire uniformly wound over the 42-cm. length. The total resistance of the magnetizing winding shall be between 0.3 and 0.5 ohm. The secondary winding of 150 turns of copper wire on each solenoid shall be similarly wound beneath the primary winding. Its resistance shall not exceed 1 ohm.

(*c*) A voltmeter and the voltage coil of a wattmeter shall be connected in parallel to the terminals of the secondary winding of the apparatus. The current coil of the wattmeter shall be connected in series with the primary winding.

(*d*) An electromotive force having a wave form approximating a sine curve shall be applied to the primary winding and adjusted until the voltage of the secondary circuit is given by the equation:

$$E = \frac{4 f N n B M}{4 l D 10^8}$$

in which

f = form factor of primary E.M.F. . . = 1.11 for sine wave
N = number of secondary turns. . . . . . = 600
n = number of cycles per second. . . . . = 60
B = maximum induction. . . . . = 10 000
M = total mass in grams. . . . . = 10 000
l = length of strips in centimeters. . . . = 50

$$D = \text{density} \ldots\ldots = \begin{cases} 7.5 \text{ for high-resistance steel} \\ 7.7 \text{ for low-resistance steel} \end{cases}$$

$$E = \begin{cases} 106.6 \text{ volts for high-resistance steel for sine voltage} \\ 103.8 \text{ volts for low-resistance steel for sine voltage} \end{cases}$$

The form factor of the applied electromotive force shall not depart more than 1 per cent from the value of 1.11. As an alternative to the use of a sine wave, the correct value of the voltage may be determined by applying it to an Epstein apparatus containing a sample which has been standardized by means of a sine wave electromotive force. The wattmeter is brought to the correct reading for the standard sample. The corresponding voltage is the correct one to use.

10. (*a*) For silicon steels, a density of 7.7 g. per cu. cm. shall be assumed if the silicon content is 2 per cent or less and a density of 7.5 g. per cu. cm. shall be assumed if the silicon content is over 2 per cent.[1]

(*b*) For nickel-iron alloys the density shall be assumed from the nickel content as given by the straight lines joining the points defined as follows:[2]

NICKEL, PER CENT	DENSITY, G. PER CU. CM.
0	7.85
30	8.00
100	8.90

---

[1] For silicon steel having a 2-per-cent silicon content the electrical resistance is 2.6 ohms per meter gram.

[2] For 50-per-cent nickel content the density is 8.26 g. per cu. cm. For 80-per-cent nickel content the density is 8.64 g. per cu. cm.

(*c*) For other alloys a density corresponding to the actual measured or estimated value shall be used.

11. The wattmeter gives the power consumed in the iron and the secondary circuit. The loss in the secondary circuit is given in terms of the total resistance and voltage. Subtracting this correction term from the total power gives the net power consumed in the steel as hysteresis and eddy-current loss. Dividing this value by ten gives the core loss in watts per kilogram.

Sampling.

12. The core-loss material shall be cut from two or more sheets taken at random from shipment. The strips should be distributed symmetrically over the sheet, as nearly as may be practicable. (See Figs. 1 and 2.)

It is recommended that a test sample shall represent not more than 5000 kg. (11,000 lb.).

Procedure.

13. (*a*) Cut the test material into strips 3 by 50 cm. as indicated in Section 13.

(*b*) Place on the balance a pile of strips weighing 2.5 kg. Add a second pile of the same kind, bringing the weight up to 5 kg. In each case the weight shall be taken to the nearest strip. Add in succession two piles of 2.5 kg. each, of the other kind of strips, bringing the weight up to 7.5 kg. and 10 kg., respectively.

(*c*) Insert in the apparatus as indicated.

NOTE.—If desired, for convenience, the bundles may be loosely secured by tape or string (not wire).

(*d*) Apply the alternating voltage to the primary coil and tap the joints together until the current has a minimum value, as shown by an ammeter in series. Then clamp the corners firmly by some suitable device.

(*e*) Shunt the ammeter and adjust the primary current until the voltmeter indicates the proper value. This adjustment may be made by an auto-transformer, by varying the field of the alternator, or by both, but not by the insertion of resistance or inductance in the primary circuit. Simultaneously the frequency must be adjusted to 60 cycles.

(*f*) Read the wattmeter.

(*g*) *Calculations.*—Subtract from the wattmeter reading the instrument losses, which will be constant for any set of instruments and voltage, and divide by 10. The result is the standard core loss.

NOTE.—If desired a 5-kg. sample may be used for routine acceptance tests, provided it is cut from at least two sheets, except in case of a dispute between the manufacturer and purchaser when the 10-kg. sample shall be used.

TENTATIVE SPECIFICATIONS
FOR
BRONZE TROLLEY WIRE[1]

Serial Designation: B 9 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism **and** suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1925; Revised, 1926.

I. MANUFACTURE

Scope. 1. These specifications cover round and grooved bronze trolley wire.

Material. 2. The material used shall be bronze of such nature and composition as to secure by proper treatment the qualities hereinafter specified for the finished wire. The copper used shall be electrolytic or low-resistance lake copper conforming in quality and purity to the requirements of either the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 5) or of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4) of the American Society for Testing Materials.[2]

Bronze of two qualities may be required:

(*a*) High Strength.

(*b*) Medium Strength.

II. PHYSICAL PROPERTIES AND TESTS

(*A*) *Round Wire.*

Tensile Strength and Elongation. 3.⚑ (*a*) Round wire shall be so drawn that its tensile strength and elongation shall not be less than the values given in Table I.

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[1] These specifications were prepared by Committee B-1 on Copper Wire in cooperation with a committee of the American Electric Railway Engineering Association. The specifications of the two organizations are identical save with respect to the requirements for the twist test, Section **4**. Further cooperative work with respect to these requirements is being undertaken.

Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

These tentative specifications, when adopted as standard, will supersede the present Standard Specifications for High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent conductivity (Serial Designation: B 9 - 16), 1924 Book of A.S.T.M. Standards.

[2] **1924 Book of A.S.T.M. Standards.**

The elongation shall be determined as the permanent increase in length due to the breaking of the wire in tension measured between bench marks placed upon the wire originally 10 in. apart. The fracture shall be between the bench marks and not closer than 1 in. to either bench mark.

(*b*) Tests upon a section of wire containing a braze shall show at least 95 per cent of the tensile strength of the unbrazed wire.

Elongation tests shall not be made on test sections including brazes.

Twist Test. 4. For the purpose of determining and developing defects which may be prejudicial to the life of trolley wire, owing to its peculiar service, as compared to that of copper wire for other purposes, round wire shall be subjected to the following twisting test. Three twist tests shall be made upon samples 10 in. in length between the holders of the machine. The twisting machine shall be so constructed that there is a linear motion of the tail stock with respect to the head. The twist shall be applied not faster than 10 turns per minute. All three samples shall be twisted to destruction and shall not reveal under test any seams, pits, slivers, or surface imperfections of sufficient magnitude to indicate inherent defects or imperfections in the wire. At the time of fracture the wire shall be twisting with reasonable uniformity. Wire shall not be considered satisfactory which does not withstand at least twenty turns before breaking.

TABLE I.—VALUES FOR TENSILE STRENGTH AND ELONGATION OF ROUND WIRE.

		HIGH-STRENGTH BRONZE WIRE		MEDIUM-STRENGTH BRONZE WIRE	
DIAMETER, IN.	AREA, CIRCULAR MILS	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 10 IN., PER CENT
0.548.....	300 000	70 000	4.50	60 000	4.50
0.460.....	211 600	73 000	3.75	62 000	3.75
0.410.....	168 100	76 000	3.25	64 000	3.25
0.365.....	133 225	79 000	2.80	66 000	2.80
0.325.....	105 625	81 000	2.40	69 000	2.40

Resistivity. 5. Electric resistivity shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.).

High-strength wire shall not exceed in resistivity 2188 lb. per mile-ohm. Medium-strength wire shall not exceed in resistivity 1346 lb. per mile-ohm.

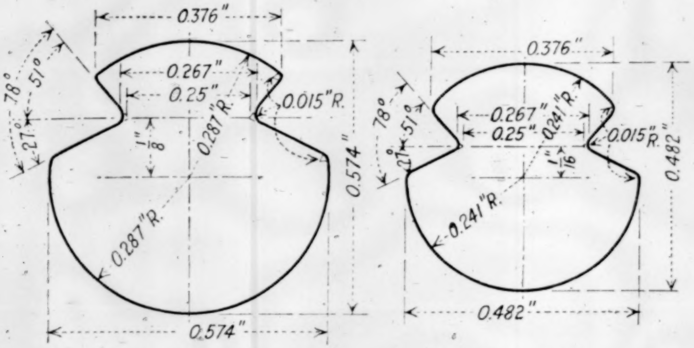
The values given above are based on bronzes of copper-tin compositions and represent classes of such wire formerly referred to as 40-per-cent and 65-per-cent conductivity wire.

Lower resistivities in wires meeting the physical qualifications of these specifications may be obtained by the use of other alloys.

(B) Grooved Wire.

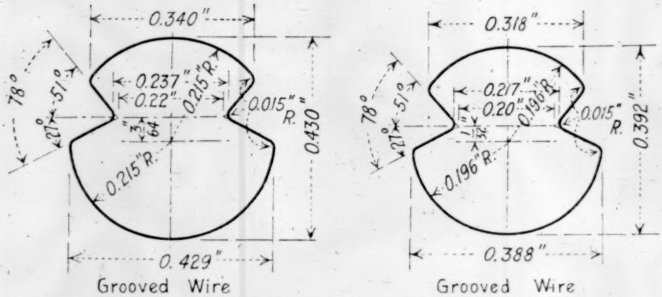
Physical Properties and Tests.

6. (*a*) The physical tests for grooved wire shall be made in the same manner as those upon the round wire. The tensile strength of grooved wire shall be at least 95 per cent of that required for round wire of the same nominal cross-sectional area; the elongation shall be the same as that required for round wire of the same nominal cross-sectional area. The twist test shall be omitted.


0.376"
78°
51°
27°
0.267"
0.25"
0.287"R.
0.015"R.
1"/8
0.574"
0.287"R.
0.574"
0.376"
78°
51°
27°
0.267"
0.25"
0.241"R.
0.015"R.
1"/16
0.482"
0.241"R.
0.482"

Grooved Wire
Nominal Cir. Mils, 300 000
Actual Area, 0.2355 sq. in.
Calculated Weight, 4792 lb.
per mile

Grooved Wire
Nominal Cir. Mils, 211 600
Actual Area, 0.1665 sq. in.
Calculated Weight, 3389 lb.
per mile


0.340"
78°
51°
27°
0.237"
0.22"
0.215"R.
0.015"R.
3"/64
0.430"
0.215"R.
0.429"
0.318"
78°
51°
27°
0.217"
0.20"
0.196"R.
0.015"R.
1"/32
0.392"
0.196"R.
0.388"

Grooved Wire
Nominal Cir. Mils, 168 100
Actual Area, 0.1314 sq. in.
Calculated Weight, 2674 lb.
per mile

Grooved Wire
Nominal Cir. Mils, 133 225
Actual Area, 0.1083 sq. in.
Calculated Weight, 2205 lb
per mile

FIG. 1.

(*b*) Tests upon a section of wire containing a braze shall show at least 95 per cent of the tensile strength of the unbrazed wire.

Elongation tests shall not be made on test sections including brazes.

7. The requirements for resistivity of grooved wire shall be the same as those for round wire of the same nominal cross-sectional area. **Resistivity.**

III. DIMENSIONS AND PERMISSIBLE VARIATIONS

8. For the purpose of calculating weights, cross-sections, etc., the density of the bronze shall be taken as 8.89 g. per cu. cm. at 20° C. (68° F.).[1] **Density.**

(*A*) *Round Wire.*

9. (*a*) The size shall be expressed as the diameter of the wire in decimal fractions of an inch, using not more than three places of decimals, *i. e.*, in mils. **Dimensions and Permissible Variations.**

(*b*) Wire shall be truly cyclindrical in form. The diameter shall not vary more than 1 per cent over or under the diameter specified.

(*B*) *Grooved Wire.*

10. Standard sections of grooved trolley wire shall be those known as the "American Standard Grooved Trolley Wire Sections" (the Standard Design of the American Electric Railway Engineering Association), shown in Fig. 1. **Sections.**

11. (*a*) Size shall be expressed as the nominal area of cross-section in circular mils, the standard sizes being as follows: **Dimensions and Permissible Variations.**

NOMINA' AREA, CIRCULAR MILS	ACTUAL AREA, SQ. IN.	CALCULATED WEIGHT BASED ON ACTUAL AREA, LB. PER MILE
300 000	0.2355	4792
211 600	0.1665	3389
168 100	0.1314	2674
133 225	0.1083	2205

(*b*) The weight of grooved trolley wire shall not vary more than 4 per cent over or under the weights specified in Paragraph (*a*).

IV. FINISH

12. (*a*) The wire shall be of uniform size, shape, and quality throughout, and shall be free from all scale, flaws, splits and scratches not consistent with the best commercial practice. **Finish.**

(*b*) Necessary brazes in trolley wire shall be made in accordance with the best commercial practice.

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[1] Bronze trolley wire is an alloy as commonly produced of not less than 98 per cent copper with other metals. Determinations of the density of these alloys indicate, as might be expected, an average density practically the same as that found for copper.

V. PACKING

Packing and Shipping. 13. All wire shall be shipped on substantial reels, suitable for the weight of the wire handled, and shall be well protected from injury. If reels are to be lagged, it shall be so specified by the purchaser.

The ends shall be securely fastened to the sides of the reels with no less than six staples. The staples shall be at least 2 in. in length and made from not less than 0.145-in. diameter wire. Care shall be exercised in stapling not to damage the surface of the exposed layer of wire. All reels shall have the arbor holes reinforced with steel plates. Reels shall be marked legibly and indelibly with a serial number, size, kind, length and weight of wire, and such other information as is desired by the purchaser. The length or weight of wire to be wound upon reels shall be agreed upon in placing individual orders.

VI. INSPECTION AND REJECTION

Inspection. 14. All tests governing the acceptance or rejection of the wire, unless otherwise specified, shall be made at the place of manufacture with apparatus furnished by the manufacturer and in the presence of the purchaser, or his representative, who shall be furnished a copy of the tests. Every facility shall be given the purchaser, or his representative, to satisfy him as to the reliability of the results before the wire is delivered. If the purchaser waives inspection, and if he so elects at that time, he shall be furnished with a certified copy of tests made by the manufacturer.

Rejection. 15. Any reel of wire which fails to meet the requirements hereinbefore specified may be rejected. Failure of 30 per cent of the number of reels ready for inspection at one time shall be deemed sufficient cause for the rejection of the whole lot.

TENTATIVE SPECIFICATIONS
FOR
SOFT RECTANGULAR COPPER WIRE[1]

Serial Designation: B 48 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1923; REVISED, 1926.

I. MANUFACTURE

Scope. 1. These specifications cover soft or annealed rectangular copper wire with rounded corners.

Material. 2. The copper shall conform in quality and purity to the requirements of either the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 4) or of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials.[2]

II. PHYSICAL PROPERTIES AND TESTS

Physical Tests. 3. The wire shall conform to the following requirements as to tensile properties:

Thickness, in.	Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent
0.003 to 0.010	......	14
0.011 to 0.020	40 000	20
0.021 to 0.050	38 500	25
0.051 to 0.289	37 000	30
0.290 to 0.500	36 000	33

The elongation shall be measured between bench marks placed upon the wire originally 10 in. apart and the fracture shall be between the bench marks and not closer than 1 in. to either bench mark. If upon testing a sample from any coil or reel, the results do not conform to the specified requirements two additional samples shall be tested and the average of the three tests shall determine acceptance or rejection of the coil or reel.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] 1924 Book of A.S.T.M. Standards.

Electric Resistivity.

4. Electric resistivity (Note 1) shall be determined upon fair samples by resistance measurements at a temperature of 20° C. (68° F.) and shall not exceed 891.58 lb. per mile-ohm.

III. DIMENSIONS AND PERMISSIBLE VARIATIONS

Dimensions and Permissible Variations.

5. (*a*) The permissible variation in thickness, above or below the specified thickness, for different widths shall not exceed the limits given in the following table (Note 2):

Specified Thickness, in.	Permissible Variations		
	½ in. or Less in Width	Over ½ in. to 1 in. in Width	Over 1 In. in Width
0.050 or less	0.001 in.	0.001 in.	0.0015 in.
0.051 to 0.100	0.001 in.	0.001 in.	0.002 in.
0.101 to 0.200	1 per cent	1 per cent	0.0025 in.
0.201 to 0.300	1 per cent	1 per cent	0.003 in.
0.301 to 0.500	0.003 in.	1 per cent	1 per cent
0.501 or over	....	1 per cent	1 per cent

(*b*) A variation of ±0.003 in. will be permitted in the width of wire 0.300 in. or less in width; wire 0.301 to 1.50 in. in width may vary ±1 per cent; wire greater than 1.50 in. in width shall not vary more than ±0.016 in. from the specified width.

(*c*) Dimensions shall be expressed in decimals of an inch.

(*d*) Rectangular wire shall have edges with corners rounded to a radius as given in the following table:

Thickness, in.	Width, 0 to 0.438 in.	Width, 0.439 to 0.625 in.	Width, 0.626 in. or Over
0.050 or less	Half Round	Half Round	Half Round
0.051 to 0.105	0.025	Half Round	Half Round
0.106 to 0.125	0.031	Half Round	Half Round
0.126 to 0.165	0.031	0.047	0.063
0.166 to 0.225	0.047	0.047	0.063
0.226 to 0.438	0.063	0.063	0.094
0.439 to 0.688	.....	0.094	0.125
0.689 and above	.....	.....	0.188

Each coil shall be gaged at three places, one near each end and one approximately at the middle. From reels, approximately 12 ft. shall be reeled off; the wire shall be gaged in six places between the second and twelfth foot from the end. A coil or reel may be rejected if the average of the measurements obtained is not within the limits specified in Paragraphs (*a*) or (*b*).

IV. FINISH

Finish.

6. (*a*) The wire shall be free from all imperfections not consistent with the best commercial practice.

(*b*) Necessary brazes shall be made in accordance with the best commercial practice.

(*c*) The copper shall be thoroughly annealed after the last drawing or rolling.

V. PACKING

Packages. 7. (*a*) Rectangular wire shall be shipped in coils or on reels as agreed upon by the purchaser and the manufacturer (Note 3).

(*b*) The wire shall be packed so as to be properly protected against injury during shipment.

(*c*) Unless otherwise agreed upon, the wire shall be shipped in continuous lengths as follows:

THICKNESS, IN.	WIDTH, IN.	MINIMUM WEIGHT PER LENGTH, LB.
Less than 0.025	0.500 or less	5
Less than 0.010	Over 0.500	5
0.010 to 0.019, inclusive	Over 0.500	10
0.025 to 0.034, "	0.500 or less	15
0.020 to 0.094, "	Over 0.500 to 0.750	25
0.020 to 0.094, "	Over 0.750 to 1.00	35
0.020 to 0.094, "	Over 1.00	50
0.035 to 0.094, "	0.500 or less	20
0.095 to 0.300, "	0.500 or less	40
0.301 to 0.500, "	0.500 or less	100
Over 0.094	Over 0.500	100

Density. 8. For the purpose of calculating weights, cross-sections, etc., the density of copper shall be taken as 8.89 g. per cu. cm. at 20° C. (68° F.) (Note 4).

VI. INSPECTION

Inspection. 9. Test and inspection shall be made at the place of manufacture. The manufacturer shall afford the inspector representing the purchaser all reasonable facilities to satisfy him that the material conforms to the requirements of these specifications.

EXPLANATORY NOTES

Soft or annealed copper wire is wire which has been drawn and rolled by customary operations and annealed, and finished by cleaning when necessary to remove scale or oxide. The wire is so soft and ductile that it is easily marred and even stretched by careless handling, hence the necessity for confining specifications and inspection to wire in packages as it leaves the manufacturer, and before being put through processes incident to its use by the purchaser.

NOTE 1.—During the year 1913 the following resistivity was agreed upon internationally as standard for annealed copper:

0.15328 ohm per meter-gram at 20° C.

This resistivity is known as the International Annealed Copper Standard[1] and is equivalent to:

875.20 ohms per mile-pound at 20° C.
0.017241 ohm per meter-millimeter squared at 20° C.
1.7241 microhms per centimeter cubed at 20° C.
0.67879 microhms per inch cubed at 20° C.
10.371 ohms per mil-foot at 20° C.

For reducing the resistance of annealed copper from one temperature to another the following temperature coefficients should be used:

At 0° C., 0.00427; at 15° C., 0.00401; at 20° C., 0.00393; at 25° C., 0.00385.

In case it is desired to express the resistivity of copper in terms of conductivity, the International Annealed Copper Standard at 20° C. should be taken as 100-per-cent conductivity, and in reporting conductivity values this standard should be mentioned. It has been deemed preferable to express the requirements in standard specifications in the terms of quantities directly measurable, rather than by reference to some quantity whose standard value is the subject of agreement only. The use of the arbitrary term "conductivity" has no more warrant than the employment of arbitrary gage numbers. Therefore, in these specifications the requirements are stated as the maximum rejection limits to the resistivity.

For the convenience of those who are accustomed to express resistivity in any one of the several more or less common units, the following table of equivalents has been prepared, giving the resistivity of copper at 20° C.

887.05 lb. per mile-ohm is equal to:
  0.15535 ohms per meter-gram,
  1.7475 microhms per centimeter-cube,
  0.68799 microhms per inch-cube,
  10.512 ohms per mil-foot.
891.58 lb. per mile-ohm is equal to:
  0.15614 ohms per meter-gram,
  1.7564 microhms per centimeter-cube,
  0.69150 microhms per inch-cube,
  10.565 ohms per mil-foot.

NOTE 2.—The use of arbitrary gage numbers to express dimensions cannot be too strongly condemned. There are many such gages in existence, and confusion is to be expected unless the particular gage to be used is specified. Many of the gages have their dimensions stated in absurd figures, such as 0.090742 in., when it is not practical to measure dimensions in the fourth decimal place by workshop tools. Definite dimensions in measurable units are evidently preferable.

NOTE 3.—Attention is called to the necessity for the purchaser and manufacturer agreeing on the package weights which will be standard under any individual contract.

NOTE 4.—Unit weights were formerly defined in these specifications on the basis of specific gravity of copper. This has been changed to basis of density to agree literally with the definition of the Annealed Copper Standard adopted by the International Electrotechnical Commission.

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[1] See U. S. Bureau of Standards *Circular No. 31* for further details.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM-BASE SAND-CASTING ALLOYS IN INGOT FORM[1]

Serial Designation: B 58 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

Material Covered.

1. These specifications cover commercial aluminum-base sand-casting alloys in ingot form for remelting. The specific gravity of these alloys does not exceed 3.0.

I. MANUFACTURE

Process.

2. The alloys may be made by any approved process.

Quality.

3. The material covered by these specifications shall be of uniform quality, and shall be free from dross, slag and other harmful contamination.

II. CHEMICAL PROPERTIES

Chemical Composition

4. The following alloys are covered by these specifications and shall conform to the following requirements as to chemical composition:

Alloy	Aluminum, per cent	Copper, per cent	Iron, per cent	Silicon, per cent	Magnesium, per cent	Manganese, per cent	Zinc, per cent	Remarks
A.....	not under 96.5	1 to 1.5	not over 0.5	not over 0.5	trace	0.7 to 2.0	trace	
B.....	not under 92.5	not over 0.6	not over 0.8	4.5 to 6.0	trace	not over 0.2	not over 0.20	
C.....	not under 90.0	7 to 8.5	....	....	....	....	not over 0.20	Total of Fe, Si, Mn, Zn and Sn not to exceed 1.70 per cent.
D....	88 to 92	6 to 8.0	not over 1.50	....	....	....	not over 2.50	Total of Si, Mn and Sn not to exceed 1.00 per cent.

Sampling.

5. (*a*) The sample for chemical analysis may be taken either by sawing, drilling or milling the ingot, and shall represent the average cross-section of the piece.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the saw dust or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

III. INSPECTION AND REJECTION

Rejection.

6. (*a*) Inspection may be made at the manufacturer's works where the alloys are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

7. Material which does not conform to the requirements of these specifications may be rejected, and if rejected shall be replaced by the manufacturer without charge to the purchaser. The full weight of the rejected material shall be returned to the manufacturer.

EXPLANATORY NOTES

The Naval Gun Factory has been the largest user of Alloy A. Its resistance to salt-water corrosion makes it suitable for marine equipment. Although very large castings have been successfully poured from it, Alloy A is generally regarded as difficult to handle in the foundry. Its proportional limit is rather low.

Alloy B possesses very good foundry characteristics; the melt is quite fluid and the solidification shrinkage is low. It is especially suitable for the production of dense non-porous castings and of intricate shapes containing both heavy and thin sections. This alloy is the most resistant to corrosion of all the commonly used aluminum casting alloys. It is somewhat more difficult to machine than the other alloys and, as in the case of Alloy A, possesses a rather low proportional limit.

Alloys C and D are similar, both being substantially aluminum-copper alloys. The composition limits are such that secondary metal can be used in the manufacture of Alloy D. While no lower limits are placed on the iron and zinc in Alloy D, it is assumed they will be present and they are stated to improve the machining qualities of the castings.

The pattern maker's shrinkage is usually taken as 0.156 in. per foot for all these alloys. The weight lies within the range of 0.096 lb. per cu. in. for Alloy B, and 0.103 lb. per cu. in. for Alloy C, corresponding to the specific gravities 2.66 and 2.85, respectively. These are approximate values, since the weights will vary with the actual compositions of the individual samples.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM BASE ALLOY SAND CASTINGS[1]

Serial Designation: B 26 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1926.

Material Covered. 1. These specifications cover commercial aluminum base alloy sand castings having a specific gravity of 3 and less.

I. MANUFACTURE

Process. 2. The alloy may be made by any approved method.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition. 3. The following alloys are described by these specifications; they shall conform to the following requirements as to chemical composition:

Alloy	Aluminum, per cent	Copper, per cent	Iron, per cent	Silicon, per cent	Magnesium, per cent	Manganese, per cent	Zinc, per cent	Remarks
A.....	not under 96.5	1 to 1.5	not over 0.5	not over 0.5	trace	0.7 to 2.0	trace	
B.....	not under 92.5	not over 0.6	not over 1.0	4.5 to 6.0	trace	not over 0.2	not over 0.20	
C.....	not under 90.0	7 to 8.5	......	......	......	......	not over 0.20	Total of Fe, Si, Mn, Zn and Sn not to exceed 1.70 per cent.
D....	88 to 92	6 to 8.0	not over 1.50	......	......	......	not over 2.50	Total of Si, Mn, and Sn not to exceed 1.00 per cent.

Sampling. 4. (*a*) The sample for chemical analysis may be taken either by sawing, drilling or milling the casting or tension test specimen and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawdust or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

These Tentative Specifications, when adopted as standard, will supersede the present Standard Specifications for Light Aluminum Casting Alloys (Serial Designation: B 26 – 21), 1924 Book of **A.S.T.M. Standards.**

III. PHYSICAL PROPERTIES AND TESTS

Tension Tests.

5. The alloys shall conform to the following minimum requirements as to tensile properties:

Alloy	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent
A	18 000	8
B	16 000	3.5
C	18 000	..
D	19 000	..

Test Specimens.

6. (*a*) Two test bars shall be an integral part of large castings, or cast separately in the case of small castings to represent a lot or melt, and shall be molded in a manner similar to the castings which they represent. If the castings are heat treated, the test bars representing such castings shall be similarly heat treated.

(*b*) The manufacturer and purchaser shall agree whether the test bars can be attached to castings, on the locations of the bars, on the castings to which bars are to be attached, on the method of casting unattached bars and whether a "cast-to-size bar" or a "machined-to-size bar" shall be used.

(*c*) The "machined-to-size bar" shall be cast according to the dimensions shown in Fig. 1, and machined to conform to the dimensions shown in Fig. 2. The "cast to size" bar shall be cast according to the dimensions shown in Fig. 2 and shall be tested without machining. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests.

7. (*a*) Tests shall as far as possible be made by heats or melts, but unless otherwise agreed, two tension tests shall be made upon each unit lot of 500 lb. or single delivery of less than 500 lb.

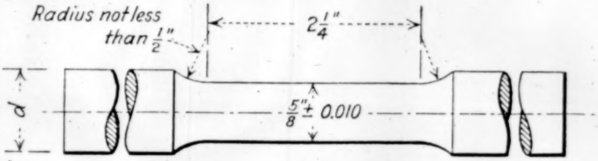
(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

IV. INSPECTION AND REJECTION

Inspection.

8. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to



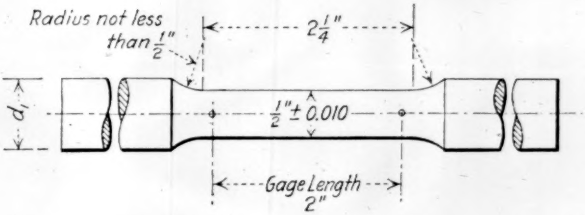
NOTE:

The Gage Length, Parallel Section and Fillets shall be as shown, but the Ends may be of any Shape to permit of Machining according to the Requirements of Fig. 2.

In Order to promote the Breaking of the Specimen in the Center it is permissible to use a Taper in the Reduced Section from the Fillets to the Center of not to exceed 0.010 in.

It is recommended, that Diameter d be from $\frac{7}{8}$" to $1\frac{1}{8}$".

FIG. 1



NOTE:

The Gage Length, Parallel Section and Fillets shall be as shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a way, that the Load shall be Axial.

In Order to promote the Breaking of the Specimen in the Center it is permissible to use a Taper in the Reduced Section from the Fillets to the Center of not to exceed 0.010 in.

It is recommended, that Diameter d_1 be from $\frac{3}{4}$" to 1."

FIG. 2

satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 9. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer free of charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

EXPLANATORY NOTES

The Naval Gun Factory has been the largest user of Alloy A. Its resistance to salt-water corrosion makes it suitable for marine equipment. Although very large castings have been successfully poured from it, Alloy A is generally regarded as difficult to handle in the foundry. Its proportional limit is rather low.

Alloy B possesses very good foundry characteristics; the melt is quite fluid and the solidification shrinkage is low. It is especially suitable for the production of dense non-porous castings and of intricate shapes containing both heavy and thin sections. This alloy is the most resistant to corrosion of all the commonly used aluminum casting alloys. It is somewhat more difficult to machine than the other alloys and, as in the case of Alloy A, possesses a rather low proportional limit.

Alloys C and D are similar, both being substantially aluminum-copper alloys. The composition limits are such that secondary metal can be used in the manufacture of Alloy D. While no lower limits are placed on the iron and zinc in Alloy D, it is assumed they will be present and they are stated to improve the machining qualities of the castings.

The pattern maker's shrinkage is usually taken as 0.156 in. per foot for all these alloys. The weight lies within the range of 0.096 lb. per cu. in. for Alloy B, and 0.103 lb. per cu. in. for Alloy C, corresponding to the specific gravities 2 66 and 2.85, respectively. These are approximate values, since the weights will vary with the actual compositions of the individual samples.

Section 5.—The elongations of Alloys C and D are usually so low as to present difficulties in their accurate measurement. The fact that a very large percentage of all aluminum castings produced in this country is made from these alloys, is evidence that the low elongation is not indicative of excessive brittleness.

Section 6.—Some latitude has been allowed in the matter of test specimens; test bars "cast to size" are stronger than those which are "machined to size" and the tensile properties specified are regularly obtained in commercial production only with the "cast to size" bar. When "machined to size" specimens are required to meet the values given in these specifications, rejections may be expected to run higher than those experienced in usual commercial production. Owing to insufficient information being available on the tensile properties of "machined to size" specimens it was not possible to include a separate table of values for this type of specimen.

It is strongly recommended that a self-centering form of tension test specimen holder be used. Most aluminum alloys are brittle and give lower and less uniform test results when tested in ordinary wedge grips without centering.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM BRONZE CASTINGS[1]

Serial Designation: B 59 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered.

1. These specifications cover alloy castings, the alloy being a composition known commercially as aluminum bronze. Two grades are specified: namely, Grade A not responding to heat treatment and Grade B capable of heat treatment.

I. MANUFACTURE

Process.

2. (*a*) The bronze may be made by any approved method.

(*b*) No scrap shall be used in the manufacture of the bronze, excepting that of known composition and origin.

(*c*) The copper used in these castings shall conform to the requirements of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4) or of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials[2] or copper of equal purity.

(*d*) The aluminum shall be that commmercially known as Grade No. 1, or that carrying less than 0.30 per cent of silicon. The iron shall be a pure grade of iron free from dirt or other detrimental foreign material.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

By adoption of this specification, the Society does not undertake to insure any one utilizing such specification against liability for infringement of any patent or assume any such liability, and such adoption does not constitute a recommendation of any patented or proprietary application that may be involved.

[2] 1924 Book of A.S.T.M. Standards.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. The bronze shall conform to the following requirements as to chemical composition:

	GRADE A	GRADE B
Copper, per cent	87 – 89	89.5 – 90.5
Aluminum, per cent	7 – 9	9.5 – 10.5
Iron, per cent	2.5 – 4	not over 1.0
Tin, max., per cent	0.5	0.2
Total other impurities, max., per cent	1.0	0.5

Chemical Analyses.

4. (*a*) An analysis of each melt may be made at the option of the purchaser and at his own expense.

(*b*) The sample for chemical analysis shall be taken from cuttings from the test bars.

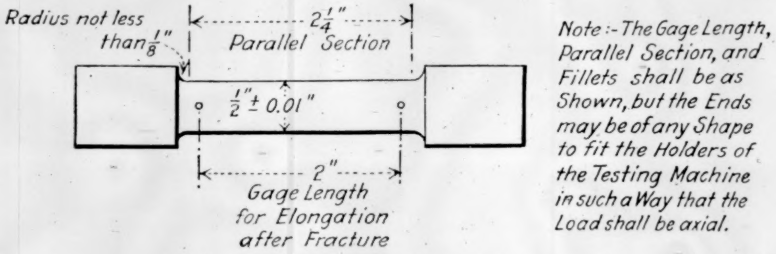
Radius not less than 1/8"
2 1/4"
Parallel Section
1/2" ± 0.01"
2"
Gage Length for Elongation after Fracture
Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG 1.—Tension Test Specimen.

III. PHYSICAL PROPERTIES AND TESTS

Tension Tests.

5. (*a*) The bronze shall conform to the following requirements as to physical properties:

	GRADE A	GRADE B
Tensile strength, min., lb. per sq. in. (as cast)	65 000	65 000
Tensile strength, min., lb. per sq. in. (as heat treated, quenched and drawn)	.....	80 000
Yield point, min. (as cast)	25 000	25 000
Yield point, min. (as heat treated)	.....	50 000
Elongation in 2 in., min., per cent (as cast)	20	15
Elongation in 2 in., min., per cent (as heat treated)	.....	4

(*b*) The yield point in tension shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

Tension Test Specimen.

6. (*a*) The tension test specimen shall be machined from coupons to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*b*) The coupon attached to the casting or cast separately in the case of small castings shall conform to the form and dimensions shown in Fig. 2. In the case of coupons cast separately, they shall be molded in a manner similar to the castings which they represent. If the castings are heat treated, the coupons representing such castings shall be similarly heat treated.

Number of Tests.

7. (*a*) Two coupons or test bars shall be cast as an integral part of large castings or cast separately in the case of small castings to represent each lot or melt of 500 lb. or less. Additional coupons may be provided at the option of the manufacturer.

(*b*) The manufacturer and purchaser shall agree whether coupons can be attached to the castings, on the location of the coupons on the castings, on the castings to which coupons are to be attached and on the method of casting unattached bars. Unless otherwise agreed upon the minimum lot shall be considered as 500 lb.

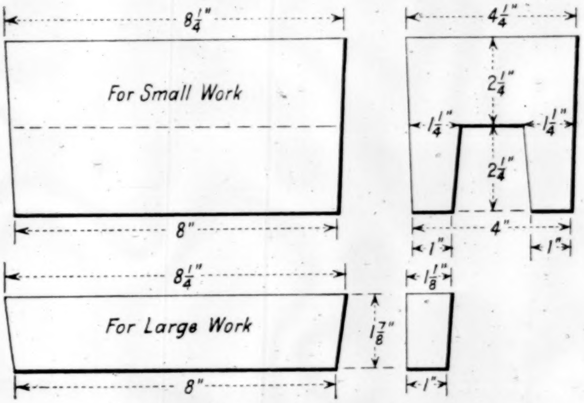

FIG. 2.—Test Specimen Coupon.

(*c*) If any test specimen shows defective machining or develops flaws it may be discarded; in which case the manufacturer and purchaser, or his representative, shall agree upon the selection of another specimen in its stead.

IV. WORKMANSHIP AND FINISH

Finish.

8. (*a*) The castings shall be free from blow holes, porosity, hard spots, shrinkage defects or cracks, or other injurious defects and shall be smooth and well cleaned, before inspection, by sand blasting, tumbling, chipping or other process approved by the inspector.

(*b*) The castings shall not be repaired, plugged, welded or "burned in," unless permission from the inspector has been previously secured. This permission will be given only when the defects are such that after the approved repair the usefulness and strength of the casting has not been impaired. Each such repair shall be encircled by a ring of white paint at the time of shipment.

(*c*) All castings shall be true to pattern, free from swells, etc. Wall thicknesses shall be uniform throughout the lot of castings and all cores shall be accurately set.

(*d*) Where thick and thin sections join, the manufacturer shall be permitted to add (where not previously provided) fillets of proper size to avoid cracking upon cooling, subject to the approval of the inspector.

V. MARKING

Marking. 9. The castings shall be marked with pattern or mark number, and when practical with the melt or lot number, at a position on the castings where they will not be machined off in manufacture to finished dimensions.

VI. INSPECTION AND REJECTION

Inspection. 10. (*a*) Inspection may be made at the manufacturer's works, or at the point of delivery. Inspection shall be made at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

TENTATIVE SPECIFICATIONS
FOR
SAND CASTINGS OF THE ALLOY: COPPER 88 PER CENT; TIN 8 PER CENT; ZINC 4 PER CENT[1]

Serial Designation: B 60 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

Material Covered.

1. (*a*) These specifications cover alloy castings, the alloy being a composition of copper, tin and zinc, known commercially as 88-8-4.

(*b*) The castings are intended for use where an excellent steam metal, withstanding in the cast state hydrostatic pressures satisfactorily, is required, such as in expansion joints, pipe fittings, valves, pumps, pump pistons and in general where good strength and resistance to salt water are required.

I. MANUFACTURE

Process.

2. (*a*) The alloy may be made by any approved method.

(*b*) The castings shall be of uniform quality.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. (*a*) The alloy shall conform to the following requirements as to chemical composition:

	Desired	Minimum	Maximum
Copper, per cent	88.00	86.00	89.00
Tin, per cent	8.00	7.50	11.00
Lead, per cent	none	....	0.30
Zinc, per cent	4.00	1.50	4.50
Iron, per cent	none	....	0.10
Nickel, per cent	....	....	0.50
Phosphorus, per cent	....	....	0.05
Aluminum, per cent	none	....	none
Sulfur, per cent	none	....	0.05
Antimony, per cent	none	....	0.25
Total other impurities, per cent	none	....	0.15

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

(*b*) Where "none" is specified it shall be construed to refer to none as determined on a 10-g. sample.

Chemical Analyses. 4. (*a*) An analysis of each melt may be made at the option of the purchaser and at his own expense.

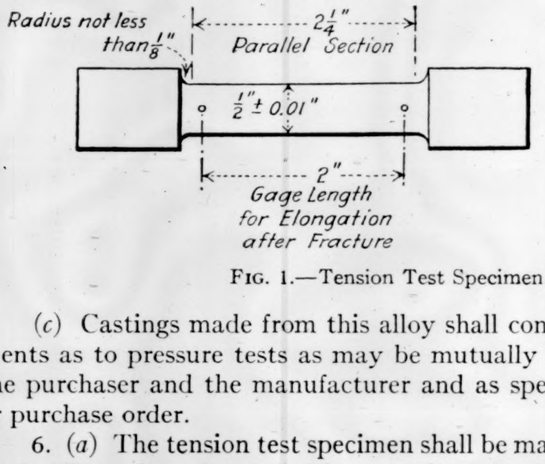
(*b*) The sample for chemical analysis shall be taken from cuttings from the test bars.

III. PHYSICAL PROPERTIES AND TESTS

Physical Requirements. 5. (*a*) The alloy shall conform to the following requirements as to tensile properties:

(*b*) The yield point shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

Tensile strength, min., lb. per sq. in.	40 000
Yield point, min., lb. per sq. in.	15 000
Elongation in 2 in., min., per cent	20


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:-The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Tension Test Specimen.

(*c*) Castings made from this alloy shall conform to such requirements as to pressure tests as may be mutually agreed upon between the purchaser and the manufacturer and as specified in the contract or purchase order.

Tension Test Specimens. 6. (*a*) The tension test specimen shall be machined from a coupon to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machines in such a way that the load shall be axial.

(*b*) The coupon attached to the casting shall be in accordance with the dimensions shown in Fig. 2. The fin gate along the side shall be not less than $\frac{5}{16}$ in. in thickness at any point along its length.

Number of Tests. 7. (*a*) Each casting weighing 250 lb. or more shall have, if practical, at least one test coupon attached. The responsibility of furnishing sufficient test specimens shall rest with the manufacturer.

(*b*) In the case of castings weighing less than 250 lb. each, at least one test coupon shall, if practical, be attached to one or more castings from each melt or heat or from such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings.

(*c*) In the case of castings where, in the opinion of the inspector, it is impracticable to attach a test coupon to the casting, bars shall be cast separately in sand. At least one test bar shall be poured from each melt or heat of metal, or such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings. The bars shall be cast from the first metal poured from the heat, and the inspector shall witness the pouring of the test mold.

(*d*) If any test specimen shows defective machining or reveals casting defects, it may be discarded and replaced by another specimen selected by the inspector. If additional test coupons are not available, the replacement specimen may be taken from the body of a casting selected by the inspector to represent the lot.

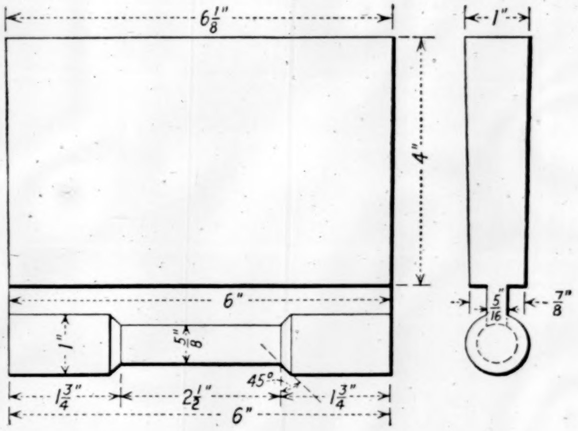


FIG. 2.—Test Specimen Coupon.

IV. WORKMANSHIP AND FINISH

8. (*a*) The castings shall be free from blow holes, porosity, hard spots, shrinkage defects or cracks, or other injurious defects and shall be smooth and well cleaned, before inspection, by sand blasting, tumbling, chipping or other process approved by the inspector. **Finish.**

(*b*) The castings shall not be repaired, plugged, welded, or "burned in" unless permission from the inspector has been previously secured. This permission will be given only when the defects are such that after the approved repair the usefulness and strength of the casting has not been impaired. Each such repair shall be encircled by a ring of white paint at the time of shipment

(*c*) All castings shall be true to pattern, free from swells, etc. Wall thicknesses shall be uniform throughout the lot of castings and all cores shall be accurately set

(*d*) Where thick and thin sections join, the manufacturer shall be permitted to add (where not previously provided) fillets of proper size to avoid cracking upon cooling, subject to the approval of the inspector.

V. MARKING

Marking. 9. The castings shall be marked with pattern or mark number, and when practical with the melt or lot number, at a position on the castings where they will not be machined off in manufacture to finished dimensions.

VI. INSPECTION AND REJECTION

Inspection. 10. (*a*) Inspection may be made at the manufacturer's works or at the point of delivery. Inspection is optional with the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

TENTATIVE SPECIFICATIONS
FOR
STEAM OR VALVE BRONZE SAND CASTINGS[1]

Serial Designation: B 61 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered.

1. These specifications cover alloy castings, the alloy being a composition of copper, tin, lead and zinc, commonly used as a high-grade steam metal or valve bronze.

I. MANUFACTURE

Process.

2. (*a*) The bronze may be made by any approved method.

(*b*) The castings shall be of uniform quality.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. (*a*) The alloy shall conform to the following requirements as to chemical composition:

	DESIRED	MINIMUM	MAXIMUM
Copper, per cent	88.00	86.00	91.00
Tin, per cent	6.50	6.00	7.00
Lead, per cent	1.50	1.00	2.00
Zinc, per cent	4.00	remainder	remainder
Iron, per cent	....	....	0.15
Nickel, per cent	....	....	0.50
Phosphorus, per cent	....	....	0.05
Aluminum, per cent	none	....	none
Antimony. per cent	....	....	0.25
Sulfur, per cent	....	....	0.05
Total other impurities, per cent	....	....	0.15

(*b*) Where "none" is specified it shall be construed to refer to none as determined on a 10-g. sample.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

Chemical Analyses. 4. (*a*) An analysis of each metal may be made at the option of the purchaser and at his own expense.

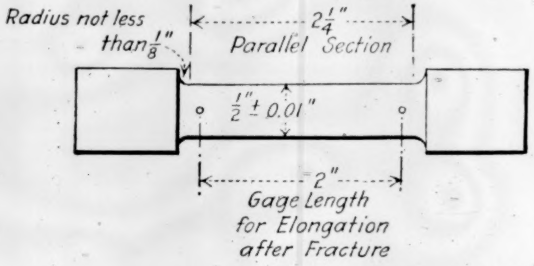
(*b*) The sample for chemical analysis shall be taken from cuttings from the test bars.

III. PHYSICAL PROPERTIES AND TESTS

Physical Requirements. 5. (*a*) The alloy shall conform to the following requirements as to tensile properties:

Tensile strength, min., lb. per sq. in.	32 000
Yield point, min., lb. per sq. in.	16 000
Elongation in 2 in., min., per cent	17

(*b*) The yield point shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Tension Test Specimen.

(*c*) Castings made from this bronze shall conform to such requirements as to pressure tests as may be mutually agreed upon between the purchaser and the manufacturer and as specified in the contract or purchase order.

Tension Test Specimen. 6. (*a*) The tension test specimen shall be machined from a coupon to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*b*) The coupon attached to the casting shall be in accordance with the dimensions shown in Fig. 2. The fin gate along the side shall be not less than $\frac{5}{16}$ in. in thickness at any point along its length.

Number of Tests. 7. (*a*) Each casting weighing 250 lb. or more shall have, if practical, at least one test coupon attached. The responsibility of furnishing sufficient test specimens shall rest with the manufacturer.

(*b*) In the case of castings weighing less than 250 lb. each, at least one test coupon shall, if practical, be attached to one or more castings from each melt or heat or from such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings.

(*c*) In the case of castings where, in the opinion of the inspector, it is impracticable to attach a test coupon to the casting, bars shall be cast separately in sand. At least one test bar shall be poured from each melt or heat of metal, or such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings. The bars shall be cast from the first metal poured from the heat, and the inspector shall witness the pouring of the test mold.

(*d*) If any test specimen shows defective machining or reveals casting defects, it may be discarded and replaced by another specimen selected by the inspector. If additional test coupons are not available, the replacement specimen may be taken from the body of a casting selected by the inspector to represent the lot.

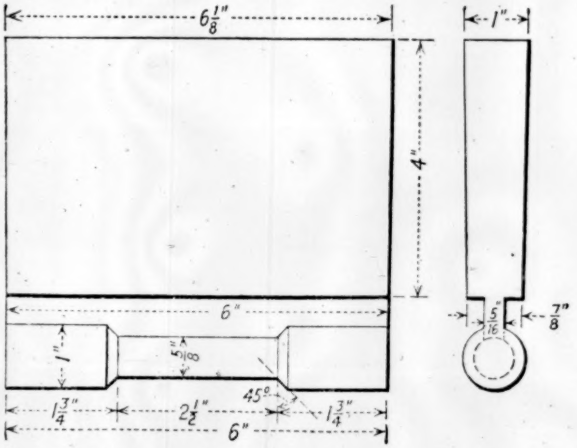


FIG. 2.—Test Specimen Coupon.

IV. WORKMANSHIP AND FINISH

Finish.

8. (*a*) The castings shall be free from blow holes, porosity, hard spots, shrinkage defects or cracks, or other injurious defects and shall be smooth and well cleaned, before inspection, by sand blasting, tumbling, chipping or other process approved by the inspector.

(*b*) The castings shall not be repaired, plugged, welded, or "burned in," unless permission from the inspector has been previously secured. This permission will be given only when the defects are such that after the approved repair the usefulness and strength of the casting has not been impaired. Each such repair shall be encircled by a ring of white paint at the time of shipment.

(*c*) All castings shall be true to pattern, free from swells, etc. Wall thicknesses shall be uniform throughout the lot of castings and all cores shall be accurately set.

(*d*) Where thick and thin sections join, the manufacturer shall be permitted to add (where not previously provided) fillets of proper size to avoid cracking upon cooling, subject to the approval of the inspector.

V. MARKING

Marking. 9. The castings shall be marked with pattern or mark number, and when practical with the melt or lot number, at a position on the castings where they will not be machined off in manufacture to finished dimensions.

VI. INSPECTION AND REJECTION

Inspection. 10. (*a*) Inspection may be made at the manufacturer's works or at the point of delivery. Inspection shall be made at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

TENTATIVE SPECIFICATIONS

FOR

COMPOSITION BRASS OR OUNCE METAL SAND CASTINGS[1]

Serial Designation: B 62 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Material Covered.

1. These specifications cover alloy castings, the alloy being a composition of copper, tin, lead and zinc, known commercially as composition metal, 85-5-5-5, or ounce metal. Castings of this alloy are commonly used in hydrostatic pressures up to 350 lb. per sq. in.

I. MANUFACTURE

Process.

2. (*a*) The alloy may be made by any approved method.

(*b*) The castings shall be of uniform quality.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Composition.

3. (*a*) The alloy shall conform to the following requirements as to chemical composition:

	DESIRED	MINIMUM	MAXIMUM
Copper, per cent	85.00	84.00	86.00
Tin, per cent	5.00	4.00	6.00
Lead, per cent	5.00	4.00	6.00
Zinc, per cent	5.00	4.00	6.00
Iron, per cent	none	....	0.25
Nickel, per cent	....	....	0.75
Phosphorus, per cent	none	....	0.05
Aluminum, per cent	none	....	none
Sulfur, per cent	....	....	0.05
Antimony, per cent	....	....	0.25
Total other impurities, per cent	....	....	0.15

(*b*) Where "none" is specified it shall be construed to refer to none as determined on a 10-g. sample.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

Chemical Analyses. 4. (*a*) An analysis of each melt may be made at the option of the purchaser and at his own expense.

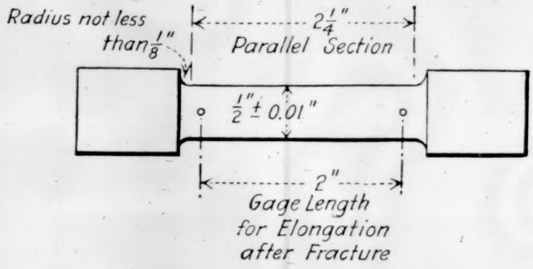
(*b*) The sample for chemical analysis shall be taken from cuttings from the test bars.

III. PHYSICAL PROPERTIES AND TESTS

Physical Requirements. 5. (*a*) Where desired by the purchaser and so specified in the contract or purchase order, the alloy shall conform to the following requirements as to tensile properties:

Tensile strength, min., lb. per sq. in	26 000
Yield point, min., lb. per sq. in	12 000
Elongation in 2 in., min., per cent	15

(*b*) Where physical requirements are not specified in the contract or purchase order a fracture of the test specimens shall be made and the fractured surface shall indicate the soundness and uniformity of the metal upon examination with the naked eye. If the test bars do not indicate a uniform soundness and quality of metal, the castings may be rejected.


Radius not less than $\frac{1}{8}$"
$2\frac{1}{4}$"
Parallel Section
$\frac{1}{2}$" ± 0.01"
2"
Gage Length for Elongation after Fracture

Note:- The Gage Length, Parallel Section, and Fillets shall be as Shown, but the Ends may be of any Shape to fit the Holders of the Testing Machine in such a Way that the Load shall be axial.

FIG. 1.—Tension Test Specimen.

(*c*) The yield point shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

(*d*) Castings made from this alloy shall conform to such requirements as to pressure tests as may be mutually agreed upon between the purchaser and the manufacturer and as specified in the contract or purchase order.

Tension Test Specimens. 6. (*a*) The tension test specimen shall be machined from coupons to the dimensions shown in Fig. 1. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

(*b*) The coupon attached to the casting shall be in accordance with the dimensions shown in Fig. 2. The fin gate along the side shall be not less than $\frac{5}{16}$ in. in thickness at any point along its length.

Number of Tests.

7. (*a*) Each casting weighing 250 lb. or more shall have, if practical, at least one test coupon attached. The responsibility of furnishing sufficient test specimens shall rest with the manufacturer.

(*b*) In the case of castings weighing less than 250 lb. each, at least one test coupon shall, if practical, be attached to one or more castings from each melt or heat or from such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings.

(*c*) In the case of castings where, in the opinion of the inspector, it is impracticable to attach a test coupon to the casting, bars shall be cast separately in sand. At least one test bar shall be poured from each melt or heat of metal, or such groups of melts or heats as the purchaser may specify, but in no case shall a lot consist of more than 1000 lb. of castings. The bars shall be cast from the first metal poured from the heat, and the inspector shall witness the pouring of the test mold.

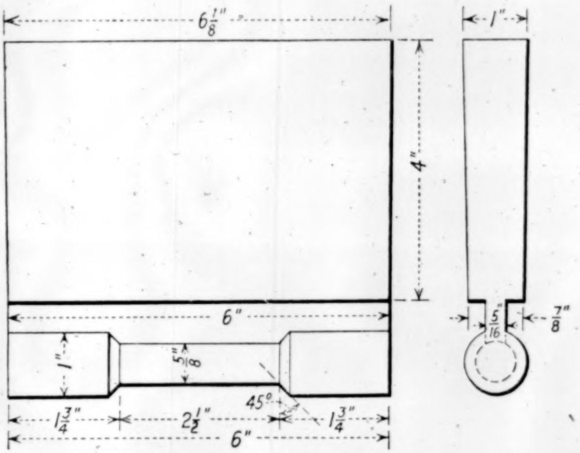


Fig. 2.—Test Specimen Coupon.

(*d*) If any test specimen shows defective machining or reveals casting defects, it may be discarded and replaced by another specimen selected by the inspector. If additional test coupons are not available, the replacement specimen may be taken from the body of a casting selected by the inspector to represent the lot.

IV. WORKMANSHIP AND FINISH

Finish.

8. (*a*) The castings shall be free from blow holes, porosity, hard spots, shrinkage defects or cracks, or other injurious defects and shall

be smooth and well cleaned, before inspection, by sand blasting, tumbling, chipping or other process approved by the inspector.

(*b*) The castings shall not be repaired, plugged, welded, or "burned in," unless permission from the inspector has been previously secured. This permission will be given only when the defects are such that after the approved repair the usefulness and strength of the casting has not been impaired. Each such repair shall be encircled by a ring of white paint at the time of shipment.

(*c*) All castings shall be true to pattern, free from swells, etc. Wall thicknesses shall be uniform throughout the lot of castings and all cores shall be accurately set.

(*d*) Where thick and thin sections join, the manufacturer shall be permitted to add (where not previously provided) fillets of proper size to avoid cracking upon cooling, subject to the approval of the inspector.

V. MARKING

Marking. 9. The castings shall be marked with pattern or mark number, and when practical with the melt or lot number, at a position on the castings where they will not be machined off in manufacture to finished dimensions.

VI. INSPECTION AND REJECTION

Inspection. 10. (*a*) Inspection may be made at the manufacturer's works or at the point of delivery. Inspection shall be made at the option of the purchaser.

(*b*) If the purchaser elects to have the inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer without charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM INGOTS FOR REMELTING[1]

Serial Designation: B 24 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1918; Revised, 1919, 1920, 1922, 1925, 1926.

Material Covered.

1. These specifications cover three grades of Virgin Aluminum, as follows:

Grade.	Aluminum, per cent.
99.5	99.5 (Minimum)
99.0	99.0 (Minimum)
98.0	98.0 (Minimum)

Impurities.

2. The presence in any of the above grades of manganese, magnesium, zinc, calcium or similar metals commonly used in the light alloys, is not admissible and such ingot cannot be classed as Virgin Aluminum under these specifications. Copper is an allowable impurity up to a maximum of 0.1 per cent in the 99.5 grade; 0.25 per cent in the 99.0 grade; and 0.45 per cent in the 98.0 grade. Iron and silicon are also allowable impurities. The sum total of the impurities, however, shall not exceed 0.5 per cent in the 99.5 grade, 1.0 per cent in the 99.0 grade, nor 2.0 per cent in the 98.0 grade.

I. MANUFACTURE.

Manufacture.

3. No scrap shall be used other than that resulting in the manufacturer's own plant from the production of material of composition similar to that specified.

II. PHYSICAL DEFECTS.

Physical Defects.

4. Aluminum ingots shall have a clean surface and shall be free from dirt, slag and foreign material.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

III. SAMPLING.

Sampling. 5. If the aluminum is shipped in carload lots, then random samples shall be taken, but not less than five ingots for each car. If the shipment is in less than carload lots, one ingot shall be taken for each 10,000 lb. (4536 kg.) or fractional part thereof.

When it is deemed necessary, a sample may be taken from each heat of 500 lb. (226.8 kg.) or more of metal.

Drilling. 6. The ingots selected shall be drilled without lubricant completely through, or half way through from top and bottom. The drillings shall be fine, thin chips. They should be thoroughly mixed and the sample for analysis should not be less than 60 g.

IV. ANALYSES.

Analyses. 7. The chemical analysis shall be made in accordance with the Tentative Methods of Chemical Analysis of Aluminum and Light Aluminum Alloys (Serial Designation: B 40 – 26 T) of the American Society for Testing Materials.[1]

V. MARKING.

Marking. 8. The maker's brand and the grade of aluminum shall be cast on each ingot. When this is not practicable, the grade shall be indicated by spotting each large ingot, or one ingot in each bundle of small ingots, with a designating color of paint: white indicating the 99.5 grade, blue, the 99.0 grade, and red, the 98.0 grade.

VI. CLAIMS.

Claims. 9. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to endeavor to reconcile the differences between the two laboratories and in the event of failure to reach an understanding, to resample the shipment, as specified in Section 3. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims. 10. The expense of the umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damage shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of metal meeting these specifications.

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[1] See p. 718.

TENTATIVE SPECIFICATIONS
FOR
ALUMINUM SHEET[1]

Serial Designation: B 25–26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1918; Revised, 1919, 1926.

I. MANUFACTURE

Manufacture.

1. No scrap shall be used in the manufacture of aluminum sheet except such as shall accumulate at the manufacturer's own plants from material of similar composition and of his own manufacture.

II. CHEMICAL PROPERTIES AND TESTS

Chemical Analyses.

2. The sheet shall contain a minimum of 99 per cent aluminum as determined by chemical analysis.

3. Samples for analysis shall be obtained from a random sheet, representing each 500 lb. (226.8 kg.) of aluminum or any lot weighing less than 500 lb. (226.8 kg.), as agreed upon between the seller and the purchaser. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire if necessary. The sample for analysis may be prepared by shearing or by drilling or machining without the use of any lubricant in such a manner as to give a sample representative of the entire cross-section of the sheet.

III. PHYSICAL PROPERTIES AND TESTS

Tension Tests.

4. *(a)* The sheet shall be supplied in the temper specified in the contract or purchase order and shall conform to the requirements as to tensile properties for the specified temper as shown in the following tables:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

Thickness		Temper No. 1: Soft		Temper No. 2: Half-Hard		Temper No. 3: Hard	
B. & S. Gage	Inches	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent
2 to 16	0.258 - 0.051	12 000	30	16 000	7	.....	..
Thinner than 10 to 16	0.102 - 0.051	.....	..	.....	..	22 000	4
" " 16 to 20	0.050 - 0.032	12 000	25	16 000	5	24 000	3
" " 20 to 24	0.031 - 0.020	12 000	20	16 000	4	26 000	2
" " 24 to 28	0.019 - 0.013	12 000	15	16 000	3	30 000	1

(*b*) Tension test specimens for sheet in Temper No. 2: Half-Hard, shall be cut from the sheet parallel to the direction of final rolling. From sheet in Temper No. 1: Soft, or Temper No. 3: Hard, the tension test specimens may be cut in any direction.

Bend Tests.

5. Bend test specimens cut in any direction from sheet in Temper No. 1: Soft or No. 2: Half-Hard shall stand being bent cold through 180 deg. flat upon themselves without cracking.

Number of Tests.

6. (*a*) One tension and one bend test specimen shall be cut from a random sheet representing each 500 lb. (226.8 kg.) of aluminum or any lot weighing less than 500 lb. (226.8 kg.), as agreed upon between the seller and the purchaser.

(*b*) Test specimens may be used for the purpose of securing samples for analysis specified in Section 3.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS

Dimensional Variations.

7. The thickness of sheets shall not vary from that specified by more than the following tolerances:

Thickness		Tolerance in Thickness, in.		
B. & S. Gage	Inches	20 in. in Width and Under	Over 20 to 36 in., Incl., in Width	Over 36 to 60 in., Incl., in Width
2 to 3........	0.258 - 0.220	±0.007	±0.008	±0.009
Thinner than 3 to 9........	0.219 - 0.115	±0.005	±0.006	±0.007
" " 9 to 13........	0.114 - 0.073	±0.003	±0.0035	±0.004
" " 13 to 21........	0.072 - 0.030	±0.0025	±0.0025	±0.003
" " 21 to 24........	0.029 - 0.019	±0.002	±0.002	±0.003
" " 24 to 27........	0.018 - 0.014	±0.002	±0.002	±0.002
" " 27.............	0.013 and less	±0.0015	±0.0015	±0.0015

V. WORKMANSHIP AND FINISH

Workmanship and Finish.

8. All sheets shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

VI. INSPECTION AND REJECTION

9. The manufacturer shall afford the inspector representing the purchaser, without charge, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. **Inspection.**

10. Materials which fails to conform to these specifications will be rejected and the manufacturer shall be notified. **Rejection.**

EXPLANATORY NOTES

In the case of sheet in the half-hard temper, there is an appreciable difference in the elongation depending upon the direction in which the test specimen is taken from the sheet. This measurement made parallel to the direction of final rolling is distinctly higher than if the specimen were cut perpendicular to this direction. This difference is not observed in hard or soft sheet. The inspection of half-hard sheet calls for the use of specimens parallel to the direction of final rolling because of the greater contrast with the values obtained from hard sheet. The fact that the bend-test specimens may be taken without regard to the direction of rolling is evidence that the lower elongation across the grain does not indicate a lack of workability.

The use of grips which insure a uniform axial loading of the test specimen is essential, if satisfactory results are to be obtained.

TENTATIVE METHODS OF CHEMICAL ANALYSIS
OF
ALUMINUM AND LIGHT ALUMINUM ALLOYS.[1]

Serial Designation: B 40 - 26 T.

This is a Tentative Standard only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1921; Revised, 1923, 1925, 1926.

The methods of analysis listed under "Analysis of Aluminum" contemplate the analysis of aluminum containing more than 98 per cent aluminum and containing only silicon, titanium, iron, copper, carbon and traces of manganese as impurities.

Unless it is positively known that such elements as tin, antimony, zinc, lead, nickel, magnesium, sodium, nitrogen or oxygen (as aluminum oxide) are absent, the methods listed under the "Analysis of Light Aluminum Alloys" should be employed.

ANALYSIS OF ALUMINUM.

(Not less than 98 per cent Aluminum.)

DETERMINATION OF SILICON AND TITANIUM.

DETERMINATION OF TOTAL SILICON.

Solutions Required.

"Acid Mixture."—1200 cc. of H_2SO_4 (25-per-cent by volume), 600 cc. HCl (sp. gr. 1.20) and 200 cc. HNO_3 (sp. gr. 1.42).

25-per-cent Sulfuric Acid.—Pour 250 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, and dilute to 1000 cc.

Method.

Dissolve 1 g. of the well-mixed sample in 35 cc. of the acid mixture in a covered flat-bottomed porcelain dish or casserole. When the drillings are completely dissolved, boil the solution to complete expulsion of HNO_3 and HCl and heat until copious fumes of H_2SO_4 have been given off for five minutes. Cool and take up the residue with 10 cc. of 25-per-cent H_2SO_4 and 100 cc. of water. Warm to complete solution of the sulfates and filter on an ashless filter paper. Wash the residue with hot water until free from sulfates and ignite in a platinum crucible. Fuse the residue with 8 to 10 times its weight of Na_2CO_3 and treat the fused mass in a casserole or beaker with 20 cc. of H_2SO_4 (1:3), washing out the crucible. Evaporate the solution until it fumes strongly to separate the SiO_2. Cool, dilute to about 100 cc., boil till the salts are dissolved, filter, wash well, ignite in a platinum crucible and weigh. Treat the ash with HF and a few drops of H_2SO_4 (1:3), carefully evaporate till dry, ignite and again weigh.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

From the difference between the two weights deduct a blank obtained from the reagents and filter. The rest of the loss in weight represents SiO_2 corresponding to the Si in the metal.

$$SiO_2 \times 0.4672 = Si.$$

NOTES.

Blanks should be carried along with all reagents and the proper corrections made.

In routine analysis, fusion of the first H_2SO_4 residue with sodium carbonate and subsequent treatment to the point of treating the ash with HF may be omitted. The first residue may be weighed and treated with HF, etc., as directed for the second H_2SO_4 residue. This, however, should not be done if the material contains much graphitic silicon or if the residue after ignition is dark colored.

DETERMINATION OF TITANIUM.

APPARATUS AND SOLUTIONS REQUIRED.

Nessler tubes or some form of colorimeter.

Hydrogen Peroxide U. S. P.—This reagent must be free from HF.

Standard Titanium Solution.—This solution is best prepared and standardized as follows:[1]

"Potassium titanium fluoride, K_2TiF_6, best serves as the starting point for the preparation of the standard solution. A quantity of this is recrystallized from boiling water one or more times, dried, and preserved in a glass-stoppered bottle. Enough of it to make 0.5 to 1 liter of the standard sulfate solution is put into a platinum dish and evaporated several times with strong sulfuric acid without bringing to dryness, till the fluorine is completely expelled. The residue is then taken up with water containing enough sulfuric acid to make at least

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[1] W. F. Hillebrand, "The Analysis of Silicate and Carbonate Rocks," *Bulletin No. 700.* U. S. Geological Survey, p. 157.

5 per cent of the latter when fully diluted. Two 50 to 100-cc. portions of the prepared solution are then further diluted, boiled, and precipitated with ammonia. The precipitates are collected on paper, washed with hot water till free from alkali, ignited moist in the filter, blasted, and weighed. Duplicates should agree almost exactly. From the weights found, the strength of the standard is calculated and the result affixed to the bottle containing it. The stopper of the bottle should be coated with vaseline and the needed quantities of solution should be withdrawn by a pipette, never poured. In a solution so prepared there is not enough alkali sulfate to weaken the color when peroxidized."

METHOD.

See "Determination of Total Silicon."

Fuse the non-volatile residue remaining after the silicon determination in a small amount of $K_2S_2O_7$, take up in a little 5-per-cent H_2SO_4 and add to the filtrates and washings from the silicon determination. Evaporate the solution to approximately 100 cc., and treat with 5 cc. H_2SO_4 (sp. gr. 1.84) and 3 g. of iron-free zinc. Heat until the zinc is nearly dissolved and the reduction of copper is complete. Decant the solution into another beaker, wash the zinc and copper with hot water and continue the evaporation of the solution to approximately 75 cc. Cool and transfer to a 100-cc. Nessler's comparison tube, add 5 cc. of 3-per-cent H_2O_2 and dilute to the 100-cc. mark. In another tube, place 88 cc. H_2O, 5 cc. of H_2SO_4 (sp. gr. 1.84) and cool. Add 5 cc. of 3-per-cent H_2O_2 and then from a burette add the standard titanium solution until the colors match. The volume of the standard solution required multiplied by 100 times its titre represents the percentage of titanium in the sample.

NOTES.

The filtrate and washings from the Silicon Determination should ordinarily be colorless. If light yellow owing to iron, the standard comparison solution should be brought to the same tint with ferric sulfate solution before adding the hydrogen peroxide.

In case the amount of titanium is high the solution may be diluted to a definite volume and aliquot portions taken for the colorimetric test.

DETERMINATION OF IRON

SOLUTIONS REQUIRED

"*Acid Mixture.*"—1200 cc. of H_2SO_4 (25-per-cent by volume), 600 cc. of HCl (sp. gr. 1.20) and 200 cc. of HNO_3 (sp. gr. 1.42)

Tartaric Acid Solution.—Dissolve 20 g. of tartaric acid crystals in 100 cc. of distilled water.

Dilute Ammonium Sulfide Solution.—Add 15 cc. of NH_4OH (sp. gr. 0.90) to 15 cc. of distilled water and saturate with H_2S; then dilute to 200 cc. with distilled water. Use freshly made.

Dilute Sulfuric Acid Solution for Reductor (5-per-cent).—Mix 50 cc. of H_2SO_4 (sp. gr. 1.84) and 1000 cc. of distilled water.

Standard Potassium Permanganate Solution.—Dissolve 1 g. $KMnO_4$ in 1000 cc. of H_2O, and allow to stand for several days in a glass-stoppered bottle in a dark closet. Filter the solution through prepared asbestos and standardize against 0.1000-g. portions of pure sodium oxalate. Each cubic centimeter is equivalent to approximately 0.00177 g. of iron.

METHOD

Dissolve 1 g. of the well-mixed sample in 35 cc. of the acid mixture and proceed as in "Determination of Silicon," including treatment with HF omitting the weighing of residues. Fuse the last residue obtained with a small amount of $K_2S_2O_7$, take up in a little 5-per-cent H_2SO_4, and add to the filtrates and washings obtained. Saturate this solution with H_2S and filter. To the filtrate add 25 cc. of the tartaric acid solution, and then with constant stirring, add NH_4OH (sp. gr. 0.90), finally drop by drop, until it is in slight excess. Pass in H_2S for a few moments, warm somewhat and allow the solution to stand. Filter and wash the sulfide precipitate thoroughly with a freshly made dilute ammonium sulfide solution, until all tartaric acid is washed out.

Dissolve the sulfide precipitate through the filter paper with warm dilute H_2SO_4 (1:10), washing the paper thoroughly, alternately with hot distilled water and with 5-per-cent H_2SO_4, using in all about 100 cc. Boil until H_2S is expelled and add, while hot, a few drops of concentrated solution of $KMnO_4$ until a distinct pink color persists. Boil again, cool and pass the solution through the reductor. Wash the beaker and reductor with 150 cc. of dilute H_2SO_4 for reductor and then with 100 cc. of distilled water. Titrate with standard $KMnO_4$ solution.

NOTES

Results of titration should be checked with a blank determination made on corresponding amounts of solutions used.

A small quantity of liquid should always be left in the reductor funnel and air should never be allowed to enter the body of the reductor.

For further details of the use of reductor see "The Chemical Analysis of Iron," by A. S. Blair, or "Quantitive Chemical Analysis," by H. P. Talbot.

The effect of tartaric acid is to form complexes with aluminum, vanadium, chromium, titanium, etc., preventing their precipitation as hydroxides.

Where the iron exists in very small quantities, a gravimetric method is preferable. In this case, double precipitation of iron sulfide is necessary to eliminate all aluminum. Dissolve the second sulfide precipitate in warm dilute H_2SO_4 (1:10), boil, and oxidize the iron with H_2O_2. Add 3 to 4 g. of NH_4Cl and then NH_4OH (sp. gr. 0.90) in considerable excess, with stirring. Filter quickly, dry and ignite the precipitate, weighing as ferric oxide. If an accurate determination of iron is desired, it is necessary to correct for the small accumulation of silica by treatment of the ignited precipitate with H_2SO_4. HF.

In adding the few drops of concentrated solution of $KMnO_4$ for oxidation, only a very slight excess is used. There may be precipitated a very slight amount of manganese oxide but this can be disregarded in passing the solution through the reductor.

DETERMINATION OF COPPER BY ELECTROLYTIC METHOD

Apparatus for Electrolysis

See the "Determination of Copper by the Electrolytic Method" in the Standard Methods of Chemical Analysis of Manganese Bronze (Serial Designation : B 27) of the American Society for Testing Materials.[1]

Solutions Required

Sodium Hydroxide Solution.—Dissolve 250 g. of NaOH in distilled water and dilute to 1000 cc.

Nitric Acid (1:1)—Pour 500 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

Method

Dissolve 10 g. of the sample in a large casserole or beaker with 150 cc. of the NaOH solution. This should be added in small portions as the action is vigorous for a time. After the action slackens, complete solution may be hastened by warming. When no evidence of further reaction can be seen, dilute to about 700 cc. with water at the boiling temperature. Filter through a strong paper and wash.

Dissolve the residue from the paper with 25 cc. of hot HNO_3 (1:1) into a beaker for electrolyzing, and wash the filter thoroughly with hot water. Boil to expel oxides of nitrogen, add 6 to 8 cc. of H_2SO_4 (1:1), dilute to about 150 cc. and electrolyze. Use a weighed sand-blasted cathode and a current of from 3 to 5 amperes at approximately 10 volts. When the solution is colorless and 1 cc. of the solution gives no copper test with H_2S water on a porcelain plate, remove the solution from the electrodes quickly without interrupting the current. Quickly rinse the cathode in distilled water and then dip it in two successive baths of alcohol. Shake off the excess alcohol and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

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[1] **1924 Book of A.S.T.M. Standards.**

NOTES

The electrolytic method is preferred for the determination of copper no matter what the percentage.

It is not anticipated that the aluminum will contain tin. In case tin has been found it will be preferable to precipitate with hydrogen sulfide. The sulfides are then to be dissolved, digested in HNO_3 (1 : 1), the metastannic acid filtered off and the electrolysis then carried out.

A staining of the anode indicates the presence of lead or manganese.

Copper, when present in small amounts, may also be determined by potassium cyanide titration. See Standard Methods of Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (Serial Designation: B 18) of the American Society for Testing Materials.[1]

DETERMINATION OF MANGANESE.

(*a*) *Persulfate Method.* (For samples containing under 1.5 per cent of Manganese.)

SOLUTIONS REQUIRED.

"Acid Mixture."—Pour 400 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and add 400 cc. of HNO_3 (sp. gr. 1.42). Then dilute the mixture with distilled water to a total volume of 2000 cc.

Silver Nitrate.—Dissolve 1.33 g. of $AgNO_3$ in 1000 cc. of distilled water.

Stock Sodium Arsenite Solution.—To 15 g. of arsenious oxide (As_2O_3) in a 300-cc. Erlenmeyer flask, add 45 g. of Na_2CO_3 and 150 cc. of distilled water. Heat the flask and contents on the steam bath until the As_2O_3 is dissolved. Cool the solution, filter and make up to 1000 cc. with distilled water.

Standard Sodium Arsenite Solution.—Mix 200 cc. of the stock sodium arsenite solution with 2500 cc. of distilled water, and standardize by the method described below against a steel or iron of known manganese content. One cubic centimeter of this solution should be equivalent to approximately 0.00050 g. of manganese.

Ammonium Persulfate.—Dissolve 6 g. of ammonium persulfate in 100 cc. of distilled water. (This solution should be made up as needed as it deteriorates rapidly.)

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[1] 1924 Book of A.S.T.M. Standards.

METHOD.

In a 250-cc. Erlenmeyer flask, dissolve 1 g. of the sample in 30 cc. of acid mixture by warming on a water bath until solution is complete. Boil until oxides of nitrogen are expelled. Dilute to 100 cc. with boiling hot water, remove the flask from the flame, add 20 cc. of $AgNO_3$ solution, and then 30 cc. of the persulfate solution. Let the solution stand on the steam bath until it has developed a full permanganate color and no bubbles can be seen to come off when the flask is given a whirling motion. Cool to below 25° C., and titrate with the standard arsenite solution to the disappearance of the pink color.

NOTES.

Large amounts (above 0.01 g. of manganese per 100 cc. of solution) of permanganic acid are unstable; the method can, however, be used with satisfaction for alloys containing high percentages of manganese by decreasing the size of the sample.

The ammonium persulfate must be tested for its strength. A good grade should contain about 95 per cent of $(NH_4)_2 S_2O_8$; some lots contain no more than 25 per cent of the salt.

If it is desired, larger amounts of the sample can be used and correspondingly greater amounts of $AgNO_3$, NaCl and $(NH_4)_2S_2O_8$ (preferably in the form of stronger solutions).

(*b*) *Bismuthate Method.* (For samples containing less than 1.50 per cent manganese.) (Optional.)

SOLUTIONS REQUIRED.

Dilute Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool and dilute to 1000 cc.

Nitric Acid (1 : 3).—Pour 250 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

Dilute Nitric Acid (3-per-cent).—Pour 30 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

Standard Permanganate Solution.—Dissolve 1 g. of $KMnO_4$ in 1000 cc. of distilled water. Allow it to stand for at least one week and then filter through purified asbestos. Standardize against 0.1 g. portions of pure sodium oxalate. One cubic centimeter of this solution should be equal to approximately 0.00035 g. of manganese.

Standard Ferrous Ammonium Sulfate Solution.—Dissolve 12.4 g. of ferrous ammonium sulfate crystals in 950 cc. distilled water, and add 50 cc. of H_2SO_4 (sp. gr. 1.84).

METHOD.

In a 250-cc. Erlenmeyer flask dissolve 0.5 g. of the sample in 10 cc. of H_2SO_4 (1 : 1), adding a drop or two of HNO_3 (sp. gr. 1.42) occasionally.

When solution is complete heat to expel all oxides of nitrogen and cool. Dilute with 50 cc. of HNO_3 (1 : 3) and add 0.5 g. sodium bismuthate. Heat for a few minutes until the purple color has disappeared with or without the precipitation of manganese dioxide. Add a little ferrous ammonium sulfate solution until the solution becomes clear and boil until the oxides of nitrogen are expelled. Cool, add an excess of sodium bismuthate and agitate for a few minutes. Add 50 cc. of 3-per-cent HNO_3 and filter through an alundum crucible or an asbestos pad. Wash with 50 cc. of 3-per-cent HNO_3. Add from a pipette or a burette 10 to 50 cc. (depending on the amount of permanganic acid) of ferrous ammonium sulfate solution and titrate with the $KMnO_4$ solution.

In exactly the same manner carry through a blank determination using the same amounts of H_2SO_4, HNO_3, and sodium bismuthate as was done with the regular sample. Finally add the exact volume of ferrous ammonium sulfate solution employed and titrate with the $KMnO_4$ solution.

The difference between the volumes required in the two titrations represents the manganese in the sample, and the percentage is found by multiplying this volume by 200 times the manganese titre of the permanganate solution.

NOTES.

Large amounts (above 0.01 g. of manganese per 100 cc. of solution) of permanganic acid are unstable; the method can be used with satisfaction for alloys containing high percentages of manganese by decreasing the size of the sample.

The filtrate from the bismuthate must be perfectly clear, as the least particle of bismuthate carried into the filtrate will vitiate the results.

The solution must be cold at time of filtration and titration.

Instead of employing the method of reducing permanganic acid by means of standardized ferrous ammonium sulfate solution and titrating the excess of the reagent, it is possible to reduce the permanganic acid by standard sodium-arsenite solution. See "Determination of Manganese by the Persulfate Method."

The sodium bismuthate reagent should be tested for manganese and used only if its absence is shown.

ANALYSIS OF LIGHT ALUMINUM ALLOYS.

DETERMINATION OF SILICON, TITANIUM AND IRON.

DETERMINATION OF TOTAL SILICON.

Proceed as described under "Determination of Silicon" in Aluminum.

NOTE.

In case lead sulfate is present (as evidenced by a white crystallin precipitate quickly settling after stirring to the bottom of the casserole) the filtered precipitate must be washed free from the sulfate with an $HN_4C_2H_3O_2$ wash solution made up as follows: Take 20 cc. NH_4OH (sp. gr. 0.90) add 20 cc. of distilled water and make slightly acid with glacial acetic acid. The final washing must be made with hot water.

DETERMINATION OF TITANIUM.

(*a*) *In the absence of nickel.*

METHOD.

Proceed as described under "Determination of Titanium" in Aluminum.

NOTE.

Vanadium, which interferes in the test, should not be encountered in this class of material. Its presence would be betrayed by an "off" reddish-brown cast in the peroxidized solution.

(*b*) *In the presence of nickel.*

METHOD.

Dissolve 1 g. of the sample as described under "Determination of Tin and Antimony" below. If the nitric acid solution of the sodium hydroxide insoluble is not clear it must be filtered, the residue burned in platinum, fused with a little $K_2S_2O_7$, dissolved in a little 5-per-cent H_2SO_4 and added to the nitric acid filtrate. Dilute the nitric acid solution to 200 cc., treat with NH_4OH (sp. gr. 0.90) until ammoniacal, boil 3 minutes, filter and wash. Dissolve the precipitate in hot dilute H_2SO_4 (25-per-cent) keeping the volume below 80 cc., cool and proceed with the colorimetric test as described under "Determination of Titanium" in Aluminum.

NOTES.

The above method provides for the color interference of copper and nickel when they are present in large amounts.

Vanadium (see Notes above) and other elements which would cause color interferences are not apt to occur in this class of material.

DETERMINATION OF IRON.

SOLUTIONS REQUIRED.

Potassium Permanganate Solution (10-per-cent).—Dissolve 10 g. of $KMnO_4$ in distilled water and dilute to 100 cc.

Dilute Sulfuric Acid for Reductor.—Mix 50 cc. of H_2SO_4 (sp. gr. 1.84) and 1000 cc. of distilled water.

Standard Potassium Permanganate Solution.—Dissolve 1 g. of $KMnO_4$ in 1000 cc. H_2O, and allow to stand for several days in a glass-stoppered bottle in a dark closet. Filter the solution through prepared asbestos and standardize against 0.1000-g. portions of pure sodium oxalate. Each cubic centimeter is equivalent to approximately 0.0018 g. of iron.

METHOD.

See "Determination of Titanium."

Transfer the solution used in the "Determination of Titanium" from the Nessler tube to a 400-cc. beaker, add 10-per-cent $KMnO_4$ solution to a good permanent pink tint and pass the solution through the reductor. Wash the beaker and reductor with 150 cc. of the H_2SO_4 for reduction and then with 100 cc. of distilled water. Titrate with the standard $KMnO_4$ solution.

The results of the titration should be corrected by a "blank" determination made on 100 cc. of a 7-per-cent H_2SO_4 solution which has been carried through as in the titanium and iron determinations, not omitting the treatment with iron-free zinc, hydrogen peroxide, and permanganate preliminary to the actual reduction. About 0.5 cc. of the permanganate solution will be required to give a permanent color to the blank.

Calculate the apparent percentage of iron. To obtain the true percentage, multiply the percentage of titanium by 1.161 and subtract.

NOTES.

For description and further details of use of reductor see "Chemical Analysis of Iron," by A. A. Blair, or "Quantitative Chemical Analysis," by H. P. Talbot.

Air should never be allowed to enter the body of the reductor.

Titanium is reduced to the trivalent condition in the reduction process and afterwards oxidized to the quadrivalent condition by the permanganate. There is a slight tendency toward oxidation in the receiver, but this may be disregarded in the small amounts of titanium ordinarily involved.

In case titanium is present and iron alone is to be determined proceed as follows: Place the H_2SO_4 solution of the sample in a 250-cc. flask, dilute to 100 cc. containing 2.5 cc. H_2SO_4 (sp. gr. 1.84) and treat with H_2S for 30 minutes in the cold and 15 minutes while warmed. If sulfides appear, filter and gas the filtrate 10 minutes more. Add 15 cc. H_2SO_4 (1 : 1) and boil vigorously until H_2S is expelled and the volume reduced to 50 cc. Fill the flask with distilled water, transfer to a beaker, and titrate with $KMnO_4$ solution.

In case the alloy contains high percentages of copper, lead, tin or antimony it is preferable to treat the combined filtrate and washings from the silicon determination with H_2S and filter off and wash the sulfates. The solution should then be boiled free from hydrogen sulfide, treated with 10-per-cent $KMnO_4$ solution to a pink tint and then reduced as directed.

Reducible elements other than iron and titanium must be absent. Such elements are chromium, vanadium, molybdenum, tungsten and uranium, and they ordinarily will not be found in this class of material.

DETERMINATION OF ANTIMONY, TIN, LEAD AND COPPER.

PRELIMINARY SEPARATION.

SOLUTIONS REQUIRED.

Sodium Hydroxide Solution (25-per-cent).—Dissolve 250 g. of NaOH in distilled water and dilute to 1000 cc. If a sediment forms on standing, decant the solution and filter through an asbestos pad. The NaOH must be entirely free from organic matter.

Nitric Acid (1 : 1).—Pour 500 cc. of HNO_3 (sp. gr. 1.42) into distilled water and dilute to 1000 cc.

METHOD.

Dissolve 5 g. of the sample in a covered porcelain dish of suitable size in 125 cc. of (25-per-cent) NaOH solution. When solution is complete dilute with 100 cc. of distilled water, decant off the clear solution and wash the residue well with hot dilute NaOH solution (2-per-cent). Treat the filtrate and washings with H_2S. If no precipitate appears, zinc is absent. In case a precipitate appears, zinc must be determined in a fresh sample as described further. Unfold the wet paper containing the NaOH insoluble and wash the residue back into the original vessel. Replace the paper in the funnel and pour 20 cc. of hot HNO_3 (1 : 1) over the paper and allow it to filter into the original vessel. Boil the residue until action ceases and oxides of nitrogen are expelled. Add 50 cc. of hot distilled water and allow to stand and settle for about one hour, keeping the temperature just below the boiling point. Filter on an ashless paper, being careful to keep the solution hot throughout the process of filtration, and reclev-ing the filtrate in a 200-cc. beaker of the tall type used in electrolysis. Wash with boiling hot water. Retain the filtrate and washings for subsequent use in the copper and lead determinations and treat the residue as described under "Determination of Antimony."

NOTES.

Antimony will be quantitatively recovered with the tin provided it does not exceed one-fifth its amount. In the rare case of high antimony evaporate the nitric acid solution of the NaOH insoluble to dryness, bake at 105° C., take up in hot 10-per-cent by volume nitric acid, and proceed with the filtration and washing.

The metastannic acid precipitate will not contain enough copper to make a recovery worth while in ordinary work. As iron is determined in a separate portion and does not interfere in the determinations of antimony and tin, it may also be disregarded.

DETERMINATION OF ANTIMONY

SOLUTIONS REQUIRED.

Standard Permanganate Solution.—The solution prepared as under "Determination of Iron" may be employed. It must be standardized against weighed 0.05-g. portions of pure antimony or suitable material of known antimony content carried through the regular procedure after solution in acid and treatment in the Kjeldahl flask.

METHOD.

See "Preliminary Separation."

Transfer the filter containing metastannic acid and antimony oxide to a 500-cc. Kjeldahl flask, add 10 to 12 cc. H_2SO_4 (sp. gr. 1.84) and 3 to 5 g. Na_2SO_4. Heat until all organic matter is decomposed. Dilute, when cool, with 20 cc. of water. Add 0.5 g. Na_2SO_3 and boil until all SO_2 is expelled from the flask. Dilute to about 250 cc., add 20 cc. of HCl (sp. gr. 1.20) cool to 10° C. and titrate with the $KMnO_4$ solution to the first definite shade of pink. Reserve the solution for the "Determination of Tin."

DETERMINATION OF TIN.

SOLUTIONS REQUIRED.

Standard Iodine Solution.—Dissolve 10.7 g. of iodine in 50 cc. of water containing 20 g. of KI in solution, and dilute to 1000 cc. *when the iodine is completely in solution.* Standardize against pure tin by the method described below.

Starch Solution.—Prepare as described under "Determination of Copper, Iodide Method."

METHOD.

See "Determination of Antimony."

Transfer the solution used in "Determination of Antimony" to a 450-cc. Erlenmeyer flask, add an excess of powdered antimony and 50 cc. of HCl (sp. gr. 1.20). Attach a reflux condenser and boil for 15 minutes on a hot plate. Cool in a current of CO_2, add 5 cc. of starch solution, and without disconnecting the stream of CO_2, titrate with the iodine solution to the blue end point.

DETERMINATION OF COPPER AND LEAD SIMULTANEOUSLY.
BY THE
ELECTROLYTIC METHOD.

APPARATUS REQUIRED.

See "Determination of Copper" under "Analysis of Aluminum."

METHOD.

See "Preliminary Separation."

Dilute the filtrate and washings from the "Preliminary Separation" to about 150 cc. with distilled water and electrolyze, using weighed sand-blasted cathode and anode. Cover with a pair of split watch glasses and use a current of from 1.25 to 1.5 amperes, at approximately 10 volts for each solution. After about one hour the lead will have been entirely deposited on the anode as PbO_2; without interrupting the current add to the electrolyte 3 to 4 cc. of H_2SO_4 (sp. gr. 1.84), wash down the cover glasses, electrodes and sides of the beaker and continue the electrolysis for 15 minutes. If no darkening of the newly-exposed anode surface can be detected and if a few drops of H_2S water added to 1 cc. of the electrolyte on a porcelain plate gives no coloration the electrolysis is complete. In this case, remove the solution from the electrodes quickly without interrupting the current. Rinse the electrodes in quick succession with distilled water and then twice with alcohol. Reserve the electrolyte and water washings for the nickel and magnesium determinations. Dry the anode at 210° C. for thirty minutes. Weigh as PbO_2, using the factor for lead 0.8643 instead of the theoretical value. Shake off the excess alcohol from the cathode and ignite the remainder by bringing it to the flame of an alcohol lamp. Keep the cathode moving continually while the alcohol burns. Weigh as metallic copper.

NOTE.

The electrolyte and water washings may be diluted to 500 cc. and one 250-cc. portion taken for the "Determination of Nickel" and the other for the "Determination of Magnesium" as directed further. If the alloy contains copper and no tin, antimony or lead the electrolytic method given under "Determination of Copper" in Aluminum may be employed.

DETERMINATION OF LEAD AS SULFATE.

(OPTIONAL.)

SOLUTIONS REQUIRED.

"Lead Acid."—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 1800 cc. of distilled water. Dissolve 1 g. of lead acetate C.P. in 300 cc. of distilled water and add this to the hot solution, stirring meanwhile. Let stand at least 24 hours and siphon through a thick asbestos filter.

Dilute Alcohol for Washing.—Mix equal parts of denatured alcohol and distilled water.

METHOD.

See "Preliminary Separation."

To the combined filtrate and washings from the "Preliminary Separation" add 120 cc. of lead acid, and evaporate until copious fumes of H_2SO_4 are evolved. Cool, add 105 cc. of distilled water to dissolve the salts and to make the concentration the same as in the lead acid, heat to boiling, and allow to cool and settle for 5 hours, or over night if convenient. Filter on a weighed porcelain Gooch crucible and wash with lead acid. Set the filtrate and washings aside for the "Determination of Copper by the Iodide Method." Continue the washing and wash out the lead acid with dilute alcohol. Set the Gooch crucible inside a porcelain crucible, dry and ignite for 5 minutes at the full heat of a Tirrill burner. Cool and weigh as $PbSO_4$, which contains 68.32 per cent lead.

DETERMINATION OF NICKEL
BY THE
DIMETHYLGLYOXIME METHOD.

SOLUTIONS REQUIRED.

Sulfuric Acid (1 : 1).—Pour 500 cc. of H_2SO_4 (sp. gr. 1.84) into distilled water, cool, and dilute to 1000 cc.

Hydrogen Sulfide Wash Water.—Add 10 cc. of H_2SO_4 (sp. gr. 1.84) to 1000 cc. of distilled water and saturate with H_2S.

Tartaric Acid Solution (20-per-cent).—Dissolve 20 g. of tartaric acid in distilled water, dilute to 100 cc. and filter if necessary.

Dimethylglyoxime Solution (1-per-cent).—Dissolve 10 g. of the reagent in 1000 cc. of 95-per-cent alcohol.

METHOD.

Dissolve 1 g. of the sample in 25 cc. of H_2SO_4 (1 : 1) as directed in "Determination of Manganese by the Persulfate Method." After oxides of nitrogen have been expelled add 14 cc. NH_4OH in order to bring down the acidity to approximately 5 cc. H_2SO_4 (sp. gr 1.84) per 100 cc. of solution. Treat with hydrogen sulfide. Filter off the sulfides, wash with hydrogen sulfide wash water and boil the filtrate until H_2S is expelled. Add a few crystals of $(NH_4)_2S_2O_8$ and boil thoroughly to destroy sulfur and oxidize iron. Add 20 cc. of tartaric acid solution and make slightly ammoniacal. If no precipitate appears add HCl (sp. gr. 1.20) to slight acidity. If a precipitate appears, dissolve in HCl add 10 cc. of tartaric acid and again make ammoniacal, repeating the operation, if necessary, to get a clear solution. To the weakly acid solution add dimethylglyoxime in such an amount that the ratio of the reagent to nickel is at least 4 : 1. Heat the solution to boiling, and make slightly ammoniacal. Allow to digest while cooling for two hours. Collect on a weighed Gooch crucible and wash thoroughly with hot water. Dry for forty-five minutes at 110 to 120° C. and weigh. The nickel dimethylglyoxime contains 20.32 per cent of nickel.

NOTES.

In case copper and lead have been determined electrolytically, nickel may be determined in one 250-cc. portion of the electrolyte and washings (see Notes), starting with the $(NH_4)_2S_2O_8$ treatment to oxidize iron and then proceeding as directed in the method above.

Nickel may be precipitated by glyoxime, filtered, dissolved in nitric acid, made ammoniacal and titrated with cyanide solution according to Frevert's method.[1]

DETERMINATION OF MAGNESIUM.

SOLUTIONS REQUIRED.

Dilute Hydrochloric Acid (1 : 1).—Pour 500 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Sulfuric Acid Wash Water.—Saturate 500 cc. of a 1-per-cent H_2SO_4 solution with H_2S.

Ammonium Sulfide Wash.—Take 10 cc. of NH_4OH, dilute to 500 cc., add 10 g. NH_4Cl and saturate with H_2S.

Microcosmic Salt Solution.—Prepare a clear saturated solution as required.

Ammoniacal Wash Solution.—Dissolve 50 g. of NH_4NO_3 in distilled water, add 50 cc. NH_4OH (sp. gr. 0.90) dilute to 1000 cc. and filter if necessary.

METHOD.

Dissolve 10 g. of the sample and wash the residue as directed under the "Preliminary Separation Determination of Antimony, Tin, Lead and Copper." Dissolve the residue in 10 cc. hot HCl (1 : 1) using a little HNO_3 if necessary. If the hydrogen sulfide group of metals are present, neutralize with NH_4OH, make weakly acid with HCl, dilute to 100 cc., heat and precipitate with hydrogen sulfide. Filter off the sulfides and wash with the H_2SO_4 wash water. To this filtrate or to the HCl solution if no H_2S treatment was required, add 5 cc. HCl (sp. gr. 1.20) make slightly ammoniacal and precipitate with H_2S. Let the solution stand for about two hours at a temperature of approximately 40° C. (at the side of the steam bath). Filter and wash with the $(NH_4)_2S$ wash. Acidify the filtrate with HCl, boil off H_2S, add $(NH_4)_2S_2O_8$ and boil to destroy sulfur if necessary. Add 1 g. of tartaric acid and 30 cc. of microcosmic salt solution. Cool, and add NH_4OH (sp. gr. 0.90) drop by drop while stirring vigorously until a crystallin precipitate begins to form. Continue the very slow addition of NH_4OH with stirring until a precipitate no longer forms and then add one-tenth the volume of NH_4OH (sp. gr. 0.90) and let stand over night. Filter and wash with cold ammoniacal wash solution. Ignite slowly under oxidizing conditions in a tared porcelain or platinum crucible and finally heat over the blast lamp or its equivalent. Weigh as $Mg_2P_2O_7$. The weight multiplied by 0.2185 represents magnesium.

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[1] A. A. Blair, "The Chemical Analysis of Iron," 8th Edition, Lippincott and Co., pp. 182–183.

NOTE.

In case copper and lead were determined electrolytically one reserved portion of the electrolyte and washings (see Notes) may be used for the determination of magnesium, starting in with the addition of 5 cc. HCl (sp. gr. 1.20) and the precipitation of the $(NH_4)_2S$ group.

DETERMINATION OF MANGANESE.

(*a*) *Persulfate or Bismuthate Method.* (For samples containing under 1.50 per cent manganese.)

Proceed as directed in "Determination of Manganese" under "Analysis of Aluminum."

(*b*) *Nitric Acid and Potassium Chlorate Method.*[1] (For samples containing over 1.50 per cent manganese.)

SOLUTIONS REQUIRED.

Hydrochloric Acid (*1 : 1*).—Mix 500 cc. of HCl (sp. gr. 1.20) and 500 cc. of distilled water.

Sulfurous Acid.—Pass SO_2 from a cylinder into 500 cc. of cold distilled water until saturated.

Bromine Water.—Place 20 to 30 cc. of liquid bromine in a 500-cc. bottle, fill with cold distilled water, and shake thoroughly. *Avoid any contact with the skin.*

Dilute Hydrochloric Acid (*1 : 3.*)—Pour 250 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Sodium-Ammonium Phosphate Solution.—Prepare this solution as needed by dissolving 1 part of the salt in 6 parts of cold water and filtering.

Ammonium Nitrate Solution.—Dissolve 100 g. of NH_4NO_3 in distilled water, make slightly ammoniacal, dilute to 1000 cc. and filter if necessary.

METHOD.

In a 250-cc. Erlenmeyer flask dissolve 1 g. of the sample in 30 cc. of. HCl (1 : 1). When solution is complete add 25 cc. HNO_3 (sp. gr. 1.42) and evaporate until the solution is almost syrupy. Add 50 cc. of HNO_3 (sp. gr. 1.42) and 5 g. $KClO_3$. Heat the solution to boiling either on the hot plate or on a tripod with a thin piece of sheet asbestos, about 1 in. (25 mm.) in diameter, on the center of the wire gauze.

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[1] A. A. Blair, "The Chemical Analysis of Iron," 8th Edition, J. B. Lippincott and Co., pp. 108-115.

Boil the solution 15 minutes, remove from the heat, add 50 cc. HNO_3 (sp. gr. 1.42) and 5 g. $KClO_3$ and boil 15 minutes longer or until yellowish fumes are no longer given off. Cool the solution rapidly in cold water and filter through asbestos. Wash two or three times with HNO_3 (sp. gr. 1.42) (free from oxides of nitrogen which dissolve the dioxide).

Transfer the dioxide with the asbestos filter to the beaker in which the precipitation was made. Pour from 10 to 40 cc. of strong sulfurous acid through the filtering apparatus into the beaker. As soon as the precipitate has dissolved, filter from the asbestos into a 150-cc. beaker, wash with hot water, and add 5 cc. HCl (sp. gr. 1.20). Heat to expulsion of SO_2, add bromine water until the solution is strongly colored with it, and boil off all excess bromine. Add NH_4OH in slight excess, boil for a few minutes, and filter into a 600-cc. beaker. Wash with hot water, remove and reserve the filtrate, and dissolve the precipitate in dilute HCl (1 : 3), allowing the solution to run back into the beaker in which the precipitation was made. Wash the filter with hot water. Boil the solution for 10 minutes to drive off any chlorine and reprecipitate by NH_4OH as before, filter into the reserved filtrate and repeat the solution, precipitation and filtration, allowing all the filtrates from the $Fe(OH)_3$ to run into the 600-cc. beaker. Acidulate this solution, which will be about 300 or 400 cc. in volume, with acetic acid, heat to boiling and treat with H_2S for 10 minutes. Filter, wash with a little dilute acetic acid saturated with hydrogen sulfide and boil off the hydrogen sulfide after adding 5 cc. of HCl (sp. gr. 1.20). Add from 5 to 20 cc. of a clear filtered solution of microcosmic salt, heat to boiling, and add NH_4OH drop by drop with constant stirring. When the precipitate begins to form, stop the addition of NH_4OH and stir until the precipitate becomes crystallin. When this change occurs add one more drop of ammonia; the additional precipitate formed will be curdy, but a few seconds stirring will change it to the silky crystallin condition. Continue the addition of NH_4OH in exactly the same manner until the precipitate is all down and further additions of NH_4OH fail to change the silky appearance. Add a dozen drops of NH_4OH in excess and cool the beaker in ice water. Filter the precipitate on an asbestos filter, wash with the cold NH_4NO_3 solution until the filtrate gives no reaction for HCl. Dry, ignite and weigh as $Mn_2P_2O_7$ which contains 38.69 per cent manganese.

NOTES.

The Ford method is recommended only where extreme accuracy is desired, otherwise use the persulfate or bismuthate methods.

If a cylinder of SO_2 is not available, hydrogen peroxide will serve equally well for the solution of the hydrated manganese dioxide.

DETERMINATION OF ZINC.

(*a*) *Samples containing up to 3 per cent of zinc.*

Solutions Required.

Dilute Hydrochloric Acid (1 : 1).—Pour 500 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Acid Wash Water.—Pour 10 cc. of H_2SO_4 (sp. gr. 1 8) into 1000 cc. of distilled water and saturate with H_2S.

Formic Acid Mixture.—Treat 400 cc. of formic acid with 60 cc. of NH_4OH (sp. gr. 0.90) and dilute to 2000 cc.

Formic Acid Wash Water.—Pour 25 cc. of formic acid mixture into 1000 cc. of distilled water and saturate with H_2S.

Dilute Hydrochloric Acid (1 : 10).—Pour 100 cc. of HCl (sp. gr. 1.20) into distilled water and dilute to 1000 cc.

Bromine Water.—See "Determination of Manganese, Nitric Acid and Potassium Chlorate Method."

Method.

Dissolve 1 g. of the sample in a covered 400-cc. beaker in 25 cc. of dilute HCl (1 : 1), with the addition of 1 cc. of HNO_3 (sp. gr. 1.42) toward the end of the reaction. Boil to expel oxides of nitrogen and dilute to 200 cc. Precipitate the H_2S group, filter and wash with acid wash water. Boil thoroughly to expel H_2S, cool, and add 5 g. of citric acid crystals. Neutralize with NH_4OH, using methyl orange as an indicator and then add 25 cc. of the formic acid mixture. Dilute to 300 cc., heat nearly to boiling and pass in H_2S until the solution is cold. Filter and wash with the formic acid wash water. Dissolve the zinc sulfide off the filter with warm dilute HCl (1 : 10) and wash the filter with hot water. Boil the solution to expel H_2S. Cool, add 1 g. of citric acid crystals, neutralize with NH_4OH, using methyl orange as an indicator and then add 20 cc. of the formic acid mixture. Dilute to 200 cc. and proceed as before through the filtration on an ashless paper and washing of the sulfide. Dissolve the precipitate with hot dilute HCl, and transfer the solution to a weighed platinum or porcelain dish or crucible. Add a few drops of H_2SO_4 (sp. gr. 1.84) and evaporate the solution until copious fumes escape. If the solution is not clear and colorless, cool, add a few cubic centimeters of HNO_3 (sp. gr. 1.42) and again evaporate the solution until fumes of H_2SO_4 come off freely. Repeat the treatment with HNO_3 if necessary, until the organic matter is destroyed, and the solution is colorless. Remove the excess of H_2SO_4 by heating the dish cautiously, and finally heat at a temperature just below dull redness. Weigh as $ZnSO_4$, which contains 40.49 per cent of zinc.

NOTE.

The use of a sodium hydroxide solution of the turnings is not recommended for the determination of zinc on account of uncertainty as to the completeness of the solution of the zinc in all cases.

(*b*) *Samples containing over 3 per cent of zinc.*[1]

SOLUTIONS REQUIRED.

Ferrous Sulfate Solution.—Dissolve 3 g. of $FeSO_4 . 7H_2O$ in distilled water, add 10 cc. of HCl (sp. gr. 1.20) and dilute to 1000 cc.

Ferrocyanide Solution.—Dissolve 44 g. of K_4FeCN_6 and 0.3 g. of K_3FeCN_6 in distilled water, dilute to 1000 cc. and age six weeks before standardization as follows: Dissolve 6 g. of zinc of known content in 40 cc. of HCl (sp. gr. 1.20) in a 2-liter flask. Cool and make up to the mark. Take 100-cc. portions, add 20 cc. of HCl (1 : 1) and add 13 cc. of NH_4OH (sp. gr. 0.90) and proceed with the titration as directed below.

METHOD.

Proceed as in the previous method until the first zinc sulfide precipitate has been obtained. Return the paper and precipitate to the original beaker and add 20 cc. of HCl (1 : 1). When the sulfide has dissolved, filter off the paper together with some sulfur and possibly a little nickel sulfide. Boil the solution containing the zinc to expel H_2S, cool, and wash down. Add 13 cc. of NH_4OH (sp. gr. 0.90) and if the solution is not alkaline, add NH_4OH carefully until it is. Make the solution barely acid again with HCl (1 : 1) and add 3 cc. of HCl (sp. gr. 1.20) in excess. Add 1 cc. of $FeSO_4$ solution, dilute nearly to 200 cc., heat almost to boiling and titrate with the K_4FeCN_6 solution. The end point is a sharp change in the color of the solution from a turquoise blue to a "pea green" and with several more drops to a "creamy yellow."

NOTE.

The end point occurs a little sooner than the one with uranium nitrate, and is easier to use, as the change is seen directly in the solution.

DETERMINATION OF SODIUM.

SOLUTIONS REQUIRED.

Dilute Nitric Acid (1 : 2).—Pour 250 cc. of HNO_3 (sp. gr. 1.42) itno distilled water and dilute to 750 cc.

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[1] Method of F. G. Breyer, 8th International Congress of Applied Chemistry, 1, 162; see also "Analysis of Copper," G. L. Heath, McGraw-Hill Book Co., pp. 250, 251.

Saturated Ammonium Carbonate Solution.—Small quantities made up as required.

METHOD.

Dissolve 5 g. of the sample in a porcelain dish in 100 cc. of dilute HNO_3 (1 : 2) by continued digestion at 50 to 60° C. When solution is complete, evaporate the solution to dryness and heat on a sand bath for several hours to complete decomposition of aluminum nitrate, but without melting any sodium nitrate formed. Cool the residue, take it up in boiling distilled water, filter and wash thoroughly. Treat the water extract with saturated $(NH_4)_2CO_3$ solution, heat to boiling and filter if a precipitate forms. Evaporate the clear filtrate in a weighed platinum dish, treat the residue with sufficient H_2SO_4 to convert the nitrate to sulfate, continue the evaporation and finally heat at 300 to 400° C. to complete expulsion of H_2SO_4. Weigh as Na_2SO_4. A blank should be carried through all operations and the proper correction applied.

DETERMINATION OF NITROGEN.

SOLUTIONS REQUIRED.

Sodium Hydroxide Solution (10-per-cent).—Dissolve 100 g. of NaOH in distilled water, dilute to 1000 cc. and filter through asbestos if the solution develops a sediment upon standing.

Approximate N/10 Sulfuric Acid Solution.—Pour 2.8 cc. of H_2SO_4 (sp. gr. 1.84) into 1000 cc. of distilled water and standardize by any standard method.

Approximate N/10 Sodium Hydroxide Solution.—Dissolve 4.5 g. of NaOH in distilled water and dilute to 1000 cc. This solution should be standardized against the standard acid solution.

METHOD.

Place 3 to 4 g. of the sample in a Kjeldahl flask fitted with a two-hole stopper carrying a separatory funnel and a trap connected with a condenser as in a Kjeldahl determination of nitrogen. Add 400 cc. of the NaOH solution through the separatory funnel, and allow the generated gas to bubble through 50 cc. of N/10 sulfuric acid solution. When the reaction has ceased, boil the alkaline solution to expel all ammonia. Finally titrate the acid with N/10 sodium hydroxide in the usual manner and calculate nitrogen.

TENTATIVE METHOD OF TEST
FOR
RESISTIVITY OF METALLIC MATERIALS FOR ELECTRICAL HEATING[1]

Serial Designation: B 63 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. This method is intended to cover the determination, to an accuracy of 1 per cent, of the electrical resistivity of rolled and drawn electrical heating materials.

Definition. 2. Resistivity is here used in the sense that it is the constant ρ in the equation

$$\rho = \frac{R\,A}{l}$$

where R is the resistance of a conductor of uniform cross-section A and of a length l.

Test Specimen. 3. In order to determine the resistivity with an accuracy of 1 per cent, it is necessary that the resistance, cross-sectional area, and length shall be measured with an accuracy of at least 0.5 per cent. To insure this accuracy, the specimens shall conform to the following:

(*a*) The specimen shall have a length of at least 1 ft.

(*b*) The specimen shall have a resistance of at least 0.001 ohm.

(*c*) If the cross-section is to be determined by direct measurement, neither the diameter, width, nor thickness shall be less than 0.05 in. or vary throughout the length of the specimen by more than 3 per cent.

(*d*) Specimens shall not show any surface cracks or other defects visible to the naked eye, and shall be free from surface oxide.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. F. E. Bash, Secretary of Committee B-4 on Metallic Materials for Electrical Heating, Technical Department, Electrical Alloy Division, Driver-Harris Co., Morristown, N. J.

I. MEASUREMENTS

Length.

4. The length may be measured by any scale which will give an accuracy of 0.5 per cent in the length measured. In case potential leads are used, the length shall be taken between the potential leads. The width of each of these leads in contact with the specimen, including soldered surface or attaching clamps, shall not be more than five thousandths of the distance between the leads.

Cross-Sectional Area.

5. In general, the diameter, or the width and thickness, shall be determined by micrometer measurements, and a sufficient number of measurements shall be made to obtain the mean cross-section to within 0.5 per cent. In case the diameter, width, or thickness is less than 0.05 in., or the geometric form is not accurately known, the cross-section shall be determined from the weight, density, and length of the specimen.

Leads.

6. In general, the specimen for the measurement of resistance shall have both current and potential leads. However, in case the resistance of the specimen is greater than one ohm, it is not necessary to employ separate potential leads. Where potential leads are used, the distance between each potential lead and the corresponding current lead shall be at least three times the maximum linear cross-sectional dimension of the specimen. Also the current leads shall be placed symmetrical with respect to the cross-section of the specimen. The resistance shall be measured by a suitable bridge or by a potentiometer method.

Heating of the Specimen.

7. In all resistance measurements, the measuring current raises the temperature of the specimen. If this is sufficient to change the resistance by 0.5 per cent, a correction shall be made. This can be determined by measuring the resistance with two known currents and computing the resistance with zero current. A convenient procedure is to use two currents, one of which is 40 per cent greater than the other. This doubles the amount of heating. The true resistance is then as much less than that determined by the normal current as the resistance determined with excess current is above that determined by normal current.

II. RECORDS

8. The record shall include the following:

   (*a*) Date of measurement.
   (*b*) Kind of material.
   (*c*) Temperature of room.
   (*d*) Length of specimen used.
   (*e*) Method of obtaining cross-section:

  - (1) If by micrometer, record all micrometer readings and give means and computed area;
  - (2) If by weighing, record length, mass, density, and computed cross-section.

(*f*) Method of measuring resistance.

(*g*) Value of resistance.

(*h*) Computed resistivity.

TENTATIVE SPECIFICATIONS
FOR
CONCRETE AGGREGATES[1]

Serial Designation: C 33 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1926.

FINE AGGREGATE

Fine Aggregate.

1. Fine aggregate shall consist of sand, stone screenings, or other inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated grains, free from injurious amounts of dust, lumps, soft or flaky particles, shale, alkali, organic matter, loam or other deleterious substances.

Grading.

2. Fine aggregate shall preferably be graded from fine to coarse, with the coarser particles predominating, within the following limits:

Passing ⅜-in. sieve		100	per cent
Passing No. 4 sieve		85	"
Passing No. 50 sieve	not more than	25	"
	not less than	5	"
Weight removed by decantation test	not more than	3	"

If these suggested detail requirements for grading of fine aggregate cannot be met in a given locality, suitable requirements for available material should be inserted.

The sieves shall conform to the requirements specified in the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (Serial Designation: C 41) of the American Society for Testing Materials.[2]

The decantation test shall be made in accordance with the Tentative Method of Decantation Test for Sand and Other Fine Aggregates (Serial Designation: D 136 - 22 T) of The American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Stanton Walker, Secretary of Committee C-9 on Concrete and Concrete Aggregates, National Sand and Gravel Association, 432 Munsey Building, Washington, D. C.

[2] 1924 Book of A.S.T.M. Standards.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 22, Part I, p. 802 (1922); also 1926 Book of A.S.T.M. Tentative Standards, p. 569.

Strength in Concrete. 3. The fine aggregate shall be tested in combination with the coarse aggregate and the cement with which it is to be used and in the proportions, including water, in which they are to be used on the work, in accordance with the requirements specified in Section 6. In case the test provided in Section 6 shows the strengths specified therein, the fine aggregate shall be considered acceptable.

Mortar Strength. 4. With the approval and consent of the engineer, the following requirements may be substituted:

(*a*) Mortar briquettes, cylinders or prisms, consisting of one part by weight of portland cement and three parts by weight[1] of fine aggregate, mixed and tested in accordance with the methods described in the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials[2] for tension tests and in accordance with the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (Serial Designation: C 9 - 16 T) of the American Society for Testing Materials[3] for compression tests shall show a tensile or compressive strength at the age of 7 and 28 days not less than that of 1:3 standard Ottawa sand mortar of the same consistency made with the same cement.

NOTE.—In testing aggregates, care should be exercised to avoid the removal of any coating on the grains which may affect the strength; bank sand should not be dried before being made into mortar, but should contain natural moisture. The percentage of moisture may be determined upon a separate sample and the weight of the sand used in the test corrected for the moisture content.

(*b*) Upon failure to meet this requirement, the proportion of cement in the concrete mixture shall be increased or the proportions of cement, fine aggregate, coarse aggregate and water changed in such a way as to produce the strength specified in Section 6.

Colorimetric Test. 5. No fine aggregate showing a color darker than the standard color when tested in accordance with the Standard Method of Test for Organic Impurities in Sands for Concrete (Serial Designation: C 40) of the American Society for Testing Materials[4] shall be used unless the strength requirement of Sections 4 or 6 is fulfilled.

Concrete Tests. 6. The grade of concrete required with its compressive strength in pounds per square inch shall be specified by the engineer. The concrete materials, including cement, fine aggregate, coarse aggregate and water, mixed in the proportions in which they are to be used in the work, and tested in accordance with the standard methods of test, shall at 28 days develop a strength of not less than that specified for the grade of concrete required. Upon failure to meet this requirement, the proportion of cement in the concrete mix shall be increased or the proportions of cement, fine aggregate, coarse aggregate and water shall be changed in such a way as to produce the specified strength.

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[1] When approved by the engineer, these proportions may be by volume, assuming 1 cu. ft. of cement to weigh 94 lb.

[2] A.S.T.M. Standards Adopted in 1926.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920); also 1926 Book of A.S.T.M. Tentative Standards, p. 242.

[4] 1924 Book of A.S.T.M. Standards.

COARSE AGGREGATE

Coarse Aggregate.

7. Coarse aggregate shall consist of crushed stone, gravel, air-cooled blast-furnace slag, or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, durable, uncoated pieces free from injurious amounts of soft, friable, thin, elongated or laminated pieces, alkali, organic or other deleterious matter.

Quality.

8. In the case of blast-furnace slag, the weight per cubic foot shall not be less than 65 lb. per cu. ft. for use in concrete structures not subject to abrasion, and not less than 70 lb. per cu. ft. for use in concrete floor or road construction.

The method of determining the weight per cubic foot of material shall be in accordance with the Standard Method of Test for Unit Weight of Aggregate for Concrete (Serial Designation: C 29) of the American Society for Testing Materials.[1]

Grading of Coarse Aggregate.

9. (*a*) Coarse aggregate shall be well graded from fine to coarse within the following limits:[2]

Passing .... in. sieve (maximum size). . . . . 95 per cent
Passing .... in. sieve (intermediate size). . . . . to .... per cent

Not more than 10 per cent shall pass the No. 4 sieve; not more than 5 per cent shall pass the No. 8 sieve.

The method of sampling concrete aggregates shall be in accordance with the Standard Methods of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods (Serial Designation: D 75) of the American Society for Testing Materials.[1]

The sieve analysis shall be made in accordance with the Standard Method of Test for Sieve Analysis of Aggregates for Concrete (Serial Designation: C 41) of the American Society for Testing Materials.[1]

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[1] 1924 Book of A.S.T.M. Standards.

[2] When there are several suitable aggregates available a thorough investigation of the relative economy of each for producing concrete of the desired strength is advisable, especially for work of considerable magnitude.

(*b*) The maximum size of coarse aggregate shall be either designated by the engineer or indicated on the plans.

NOTE.—The grading as above specified is intended to secure uniformity of aggregate, but will be governed by local conditions. The following table indicates desirable gradings, in percentes, for coarse aggregate for certain maximum sizes:

Maximum Size of Aggregate, in.	Square Openings, in.							Per Cent Passing No. 4 Sieve, not more than	Per Cent Passing No. 8 Sieve, not more than
	3	2½	2	1½	1	¾	½		
3	95	..	..	40–75	..	..	..	10	5
2½	..	95	..	..	40–75	..	..	10	5
2	..	..	95	..	40–75	..	..	10	5
1½	..	..	..	95	..	40–75	..	10	5
1	..	..	..	..	95	..	40–75	10	5
¾	..	..	..	..	..	95	..	10	5

TENTATIVE SPECIFICATIONS
FOR
GYPSUM MOLDING PLASTER[1]

Serial Designation: C 59 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Definition. 1. Gypsum molding plaster is a material employed in the making of interior embellishments, cornices, etc., and consists essentially of calcined gypsum.

I. PROPERTIES

Composition. 2. Gypsum molding plaster shall contain not less than 80 per cent of calcined gypsum ($CaSO_4 \cdot \frac{1}{2}H_2O$).

Time of Setting. 3. Gypsum molding plaster shall set in not less than 20 nor more than 40 minutes.

Tensile Strength. 4. Gypsum molding plaster shall have a tensile strength of not less than 200 lb. per sq. in. (14.0 kg. per sq. cm.).

Fineness. 5. Gypsum molding plaster shall all pass a No. 30 sieve and not less than 90 per cent of it shall pass a No. 100 sieve.

II. SAMPLING

Sampling. 6. At least 3 per cent of the packages shall be sampled and shall be so selected as to be representative of the contents of the shipment. Samples shall be taken from both the surface and the center of the packages. The material so obtained shall be thoroughly mixed and reduced by quartering to provide not less than a 15-lb. (6.75 kg.) sample for the laboratory.

Laboratory Samples. 7. All laboratory samples shall immediately be placed in an air-tight containers and shipped to the laboratory for test.

III. METHODS OF TESTING

Methods of Testing 8. The chemical and physical properties of gypsum molding plaster shall be determined in accordance with the Standard Methods of Testing Gypsum and Gypsum Products (Serial Designation: C 26) of the American Society for Testing Materials.[1]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

NOTE.—The water used for mixing gypsum plasters shall be fresh, pure and clean. Trouble may occur from the presence of any excessive amount of mineral or organic substances in the water.

IV. PACKING AND MARKING

Packing and Marking.

9. (*a*) Gypsum molding plaster shall be dry and free from lumps and may be shipped in 100-lb. cloth sacks, 100-lb. paper-lined cloth sacks, 80-lb. paper sacks or 250-lb. (235 lb. net) barrels.

(*b*) When shipped for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Brand;
Description;
Net weight of package.

V. INSPECTION AND REJECTION

Inspection.

10. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carrier being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection.

11. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing.

12. Claim for rehearing shall be valid only if made within 20 working days from receipt of notice of specific cause for rejection.

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[1] 1924 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS
FOR
GYPSUM POTTERY PLASTER[1]

Serial Designation: C 60 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Definition. 1. Gypsum pottery plaster is a gypsum product employed in the making of pottery and terra cotta molds, and consists essentially of calcined gypsum.

I. PROPERTIES

Composition. 2. Gypsum pottery plaster shall contain not less than 90 per cent of calcined gypsum ($CaSO_4 \cdot \frac{1}{2}H_2O$).

Time of Setting. 3. Gypsum pottery plaster, when mixed in accordance with the requirements of Section 8, shall set in not less than 20 minutes nor more than 40 minutes.

Tensile Strength. 4. Gypsum pottery plaster, when mixed in accordance with the requirements of Section 8, shall have a tensile strength of not less than 250 lb. per sq. in. (17.5 kg. per sq. cm.).

Fineness. 5. Gypsum pottery plaster shall all pass a No. 30 sieve and not less than 94 per cent of it shall pass a No. 100 sieve.

II. SAMPLING

Sampling. 6. At least 3 per cent of the packages shall be sampled and shall be so selected as to be representative of the contents of the shipment. Samples shall be taken from both the surface and the center of the packages. The material so obtained shall be thoroughly mixed and reduced by quartering to provide not less than a 15-lb. (6.75 kg.) sample for the laboratory.

Laboratory Samples. 7. All laboratory samples shall immediately be placed in an air-tight containers and shipped to the laboratory for test.

III. METHODS OF TESTING

Methods of Testing. 8. The chemical and physical properties of gypsum pottery plaster shall be determined in accordance with the Standard Methods of Testing Gypsum and Gypsum Products (Serial Designation: C 26) of the American Society for Testing Materials,[1] except that in the measurement of the setting time and tensile strength, the plaster and water shall be mixed in the proportion of 100 g. of plaster to 60 cc. of water.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

NOTE.—The water used for mixing gypsum plasters shall be fresh, pure and clean. Trouble may occur from the presence of any excessive amount of mineral or organic substances in the water.

IV. PACKING AND MARKING

Packing and Marking.

9. (*a*) Gypsum pottery plasters shall be dry and free from lumps and may be shipped in 100-lb. cloth sacks, 100-lb. paper-lined cloth sacks, 80-lb. paper sacks or 250-lb. (235 lb. net) barrels.

(*b*) When shipped for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Brand;
Description;
Net weight of package.

V. INSPECTION AND REJECTION

Inspection.

10. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carrier being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection.

11. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing.

12. Claim for rehearing shall be valid only if made within 20 working days from receipt of notice of specific cause for rejection.

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[1] 1924 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS
FOR
KEENE'S CEMENT[1]

Serial Designation: C 61 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Definition. 1. Keene's cement is anhydrous calcined gypsum, the set of which is accelerated by the addition of other materials.

I. PROPERTIES

Time of Setting. 2. Keene's cement shall not set in less than 16 hours nor more than 30 hours.

Tensile Strength. 3. Keene's cement shall have a tensile strength of not less than 450 lb. per sq. in. (31.5 kg. per sq. cm.).

Fineness. 4. Keene's cement shall all pass a No. 14 sieve, not less than 98 per cent shall pass a No. 40 sieve and not less than 80 per cent shall pass a No. 100 sieve.[2]

II. SAMPLING

Sampling. 5. At least 3 per cent of the packages shall be sampled and shall be so selected as to be representative of the contents of the shipment. Samples shall be taken from both the surface and the center of the packages. The material so obtained shall be thoroughly mixed and reduced by quartering to provide not less than a 15-lb. (6.75 kg.) sample for the laboratory.

Laboratory Samples. 6. All laboratory samples shall immediately be placed in an air-tight containers and shipped to the laboratory for test.

III. METHODS OF TESTING

Methods of Testing. 7. The chemical and physical properties of Keene's cement shall be determined in accordance with the Standard Methods of Testing

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

[2] Various manufacturers offer to the trade several grades of Keene's cement based upon fineness. However, it is believed that the grading permitted by this specification is sufficiently liberal to eliminate only such sizing as would be prohibitive of good results.

Gypsum and Gypsum Products (Serial Designation: C 26) of the American Society for Testing Materials.[1]

IV. PACKING AND MARKING

Packing and Marking.

8. Keene's cement may be shipped in either packages or in bulk.

(*a*) When shipped for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Brand;
Description;
Net weight of package.

(*b*) When shipped in bulk, a card containing the required information shall be conspicuously placed in the carrier.

V. INSPECTION AND REJECTION

Inspection.

9. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection.

10. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications and shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing.

11. Claims for rehearing shall be valid only if made within twenty working days from receipt of notice of specific cause for rejection.

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[1] 1924 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
HOLLOW BURNED-CLAY FIREPROOFING, PARTITION AND FURRING TILE[1]

Serial Designation: C 56 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1924; REVISED, 1926.

SPECIFICATIONS

Application. 1. These specifications apply to hollow fireproofing, partition and furring tile made from surface clay, shale, fire clay or admixtures thereof.

I. CLASSIFICATION

Classification. 2. (*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following requirements:[2]

Class	Absorption, per cent		Compressive Strength Based on Net Area, lb. per sq. in.			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard	12 or less	15	3000 or more	2500	2000 or more	1500
Medium	12 to 20	25	3000 to 2000	1500	2000 to 1250	1000
Soft	20 to 28	35	2000 to 1000	750	1250 to 750	500

(*b*) Where end-construction tiles are used on the side they shall meet the requirements of that construction, and *vice versa*.

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed to Mr. H. D. Foster, Secretary of Committee C-10 on Hollow Masonry Building Units, U. S. Bureau of Standards, Washington, D. C.

[2] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification.

II. WEIGHTS

Weights.

3. (*a*) The tile shall have the following dry weights determined as hereinafter specified:

STANDARD PARTITION TILE

Dimensions, in.	Minimum Number of Cells	Standard Weight, lb.
3 by 12 by 12	3	15
4 by 12 by 12	3	16
6 by 12 by 12	3	22
8 by 12 by 12	4	30
10 by 12 by 12	4	36
12 by 12 by 12	4	40

(*b*) A tolerance of 5 per cent will be allowed on the above standard weights.

III. DIMENSIONS

Dimensions.

4. No dimension shall vary more than 3 per cent from the standard dimensions for any form of tile.

IV. FIRE RESISTANCE

Fire Resistance.

5. In cases where the fire resistance is an essential property the purchaser shall specify the degree of fire resistance (fire-resistance period) required, and the manufacturer shall supply such available information on the fire test performance of the given or closely similar product as will aid the purchaser in deciding whether the requirements are met. Further tests in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (Serial Designation: C 19 – 26 T) of the American Society for Testing Materials[1] may be conducted by the purchaser.

V. WORKMANSHIP AND FINISH

Workmanship.

6. All tile shall be well burned, reasonably free from laminations and from such cracks, blisters, surface roughness and other defects as would evidently interfere with the proper setting of the tile or impair the permanence of the construction.

Scoring.

7. The exterior surface of all tile intended for plaster shall be scored in such a manner as to give good adhesion.

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[1] See p. 761.

VI. MARKING

8. All tile shall bear the initials, name or trademark of the manufacturer. Hollow tile intended for use in partitions shall also be marked "PARTITION." These marks shall be indented on the exterior of the tile and shall be plainly legible. **Marking.**

VII. INSPECTION AND REJECTION

9. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified in the contract. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified above. All tests shall be made in accordance with the methods hereinafter prescribed. **Inspection.**

10. (*a*) Individual tile shall be rejected for failure to meet the weight, size, or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class specified, the seller may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the seller. In case the second set of samples fails to meet the test requirements, the entire lot shall be rejected. **Rejection.**

(*b*) By agreement, acceptance may be based on dry weight of the units, percentage of absorption, fire resistance and the workmanship and finish. **Acceptance.**

11. Except as specified in Section 10, and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser. **Expense of Tests.**

TESTS

VIII. SAMPLING

12. Samples of tile for testing shall be selected by the purchaser or by a competent representative authorized by him to do this work. In all cases the samples shall be representative of the whole lot of tile from which they are selected. Full-size tile shall be taken in all cases. **Selection of Samples for Test.**

13. For the strength, absorption, and weight determinations, five individual tile shall be selected from each kiln or from each 100-ton lot. In no case shall less than five tile be taken. For the fire test the size of the test panel will govern the number of tile required. **Number of Samples.**

14. Samples for the strength and absorption tests shall be selected at the factory or at the site of the work, as specified in the contract. If the fire tests are to be made, it shall be so specified at the time of placing the order, samples being selected at the factory at least 45 days in advance of the time of filling the order. **Time and Place of Selecting Samples.**

Marking Samples. 15. All tile selected for test shall be plainly and permanently marked for reference by the testing operator.

IX. WEIGHT DETERMINATIONS

Weight Determinations. 16. The five tile, if not in kiln-dry condition, shall be dried to constant weight at a temperature of not less than 100° C. (212° F.) and be weighed separately. The scale shall be sensitive to within 0.5 per cent of the weight of the smallest unit.

X. STRENGTH TESTS

Samples. 17. Five full-size dry tile shall be used.

Speed of Testing Machine. 18. The speed of the moving head of the testing machine shall not be more than 0.05 in. per minute.

Bearing Block. 19. A spherical bearing block of proper design shall be placed on top of the test sample.

Capping. 20. (*a*) Bearing surfaces of the test samples and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with one coat of shellac and allowed to dry. A quantity of plastic mortar made of a mixture of three parts (by volume) of portland cement and one part of unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plain surface which has been coated with oil, and allowed to harden sufficiently to bear the weight of the tile. The surface to be capped shall be placed on this mortar, and while holding the specimen so that its axis is at right angles to the capping surface it shall be given a single firm pressure.

(*b*) The average thickness of the cap after the extruded plaster has been removed and the edges trued shall not be more than $\frac{1}{8}$ in. Patching of caps after setting shall not be permitted. Imperfect caps shall be removed and replaced with new ones.

(*c*) Where time is not available for aging the cement-gypsum cap, a cap of neat gypsum may be used, although the resulting tile strength will generally be lower than with the cement-gypsum cap. Any other method of capping which produces equally satisfactory results may be used.

Time of Testing. 21. When the cement-gypsum cap is used it shall age at least three days before the tile is tested. Where the neat gypsum cap is used the tile may be tested as soon as the plaster has been well set, but not sooner than one hour after the sample has been capped.

Position of Tile. 22. All tile shall be tested in the position in which they are designed to be used.

XI. ABSORPTION TESTS

Selection of Test Samples.

23. The samples shall consist of five tile or three representative pieces from each of these five tile. If small pieces are used two shall be taken from the shell and one from an interior web, the weight of each piece to be not less than 227 g. (½ lb.). The samples shall have had their rough edges or loose particles ground off and be free from cracks from the failure of the tile in compression, where taken from tile which have been subjected to strength tests.

Marking Test Samples.

24. Each piece shall be marked so that it may be identified at any time with the tile from which it was taken. Markings which do not cover more than 5 per cent of the total superficial area of the piece shall be used.

Drying the Test Samples.

25. Preparatory to the absorption tests all samples shall be dried to constant weight in a drier or oven at a temperature of not less than 100° C. (212° F.).

Accuracy of Weighings.

26. The balance used shall be sensitive to within 0.2 per cent of the weight of the smallest unit or piece tested.

Saturation of Samples.

27. After obtaining the dry weight of the samples they shall be immersed in soft, distilled or rain water, raised to the boiling point and boiled continuously for one hour, and then allowed to cool in water to room temperature.

Obtaining Saturated Weights.

28. After saturation, the sample shall be removed from the water and allowed to drain for not more than one minute. The superficial water shall be removed with a damp cloth, after which they shall be weighed immediately.

Calculating and Reporting Results.

29. The test results shall be calculated as percentages of the initial dry weight, carried to the nearest first decimal place. The results shall be reported separately for each tile, with the average for the five tile.

TENTATIVE SPECIFICATIONS AND TESTS
FOR
HOLLOW BURNED-CLAY FLOOR TILE[1]

Serial Designation: C 57 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1924; REVISED, 1926.

SPECIFICATIONS

Application. 1. These specifications apply to hollow floor tile made from surface clay, shale, fire clay or admixtures thereof.

I. CLASSIFICATION

Classification. 2. (*a*) According to the results of physical tests, tile shall be classified as Hard, Medium, and Soft on the basis of the following requirements:[2]

Class	Absorption, per cent		Compressive Strength Based on Net Area, lb. per sq. in.			
			End Construction		Side Construction	
	Mean of 5 Tests	Individual Maximum	Mean of 5 Tests	Individual Minimum	Mean of 5 Tests	Individual Minimum
Hard............	12 or less	15	4000 or more	3200	2500 or more	2000
Medium.........	12 to 16	19	4000 to 3000	2400	2500 to 1800	1400
Soft.............	16 to 25	28	3000 to 2200	1700	1800 to 1300	1000

(*b*) Where end-construction tile are used on the side they shall meet the requirements of that construction, and *vice versa*.

II. WEIGHTS

Weights. 3. (*a*) The tile shall have the following dry weights determined as hereinafter specified:

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed to Mr. H. D. Foster, Secretary of Committee C-10 on Hollow Masonry Building Units, U. S. Bureau of Standards, Washington, D. C.

[2] As different types of clay are used in the manufacture of tile, color cannot be taken as indicative of classification.

FLAT ARCH

DEPTH OF ARCH, IN.	AVERAGE WEIGHT PER SQUARE FOOT OF FLOOR, LB.
6	26
7	29
8	32
9	35
10	38
12	42
15	50

SEGMENTAL ARCH

DEPTH OF ARCH, IN.	AVERAGE WEIGHT PER SQUARE FOOT OF FLOOR, LB.
6	30
8	36
10	40

TILE FOR USE IN COMBINATION HOLLOW TILE AND CONCRETE CONSTRUCTION

SIZE OF UNIT, IN.	MINIMUM NUMBER OF CELLS	STANDARD WEIGHT, LB.
4 by 12 by 12	3	16
6 by 12 by 12	3	22
8 by 12 by 12	4	30
10 by 12 by 12	4	36
12 by 12 by 12	4	40

(*b*) A tolerance of 5 per cent will be allowed on the above standard weights.

III. DIMENSIONS

Dimensions.

4. No dimension shall vary more than 3 per cent from the standard dimensions for any form of tile.

IV. FIRE RESISTANCE

Fire Resistance.

5. In cases where the fire resistance is an essential property the purchaser shall specify the degree of fire resistance (fire-resistance period) required, and the manufacturer shall supply such available information on the fire test performance of the given or closely similar product as will aid the purchaser in deciding whether the requirements are met. Further tests in accordance with the Tentative Specifications for Fire Tests of Building Construction and Materials (Serial Designation: C 19 – 26 T) of the American Society for Testing Materials[1] may be conducted by the purchaser.

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[1] See p. 761.

V. WORKMANSHIP AND FINISH

Workmanship. 6. All tile shall be well burned, reasonably free from laminations and from such cracks, blisters, surface roughness and other defects as would interfere with the proper setting of the tile or impair the strength or permanence of the construction.

Scoring. 7. The exterior surface of all tile intended for plaster shall be scored in such a manner as to give good adhesion.

VI. MARKING

Marking. 8. All tile shall bear the initials, name or trademark of the manufacturer. These marks shall be indented on the exterior of the tile and shall be plainly legible.

VII. INSPECTION AND REJECTION

Inspection. 9. Proper facilities shall be provided the purchaser for sampling and inspection either at the factory or at the site of the work, as may be specified. At least 10 days from the time of sampling shall be allowed for the completion of the test. The inspection shall be based on the requirements specified above. All tests shall be made in accordance with the methods hereinafter prescribed.

Rejection. 10. (*a*) Individual tile shall be rejected for failure to meet the weight, size, or workmanship and finish requirements. In case of failure to meet the absorption and strength requirements for the class specified, the seller may sort the shipment and new samples shall be selected by the purchaser from the retained lot and tested at the expense of the seller. In case the second set of samples fails to meet the test requirements the entire lot shall be rejected.

Acceptance. (*b*) By agreement, acceptance may be based on dry weight of the units, percentage absorption, fire resistance and the workmanship and finish.

Expense of Tests. 11. Except as specified in Section 10 and unless otherwise agreed, the expense of inspection and testing shall be borne by the purchaser.

TESTS

VIII. SAMPLING

Selection of Samples for Test. 12. Samples of tile for testing shall be selected by the purchaser or by a competent representative authorized by him to do this work. In all cases the samples shall be representative of the whole lot of tile from which they are selected. Full-size tile shall be taken in all cases.

Number of Samples. 13. For the strength, absorption, and weight determinations, five individual tile shall be selected from each kiln or from each 100-ton lot. Where tile of several designs are used, enough samples shall be weighed to determine the true average weight in pounds per square foot for the construction. In no case shall less than five tile be taken. For the fire test the size of the test panel will govern the number of tile required. Samples for the freezing tests shall be taken from tile that have not been subjected to strength or fire tests.

Time and Place of Selecting Samples. 14 Samples for the strength and absorption tests shall be selected at the factory or at the site of the work, as specified in the contract. If the fire tests are to be made, it shall be so specified at the time of placing the order, samples being selected at the factory at least 45 days in advance of the time of filling the order.

Marking Samples. 15. All tile selected for test shall be plainly and permanently marked for reference by the testing operator.

IX. WEIGHT DETERMINATIONS

Weight Determinations. 16. The five tile, if not in kiln-dry condition, shall be dried to constant weight at a temperature of not less than 100° C. (212° F.) and be weighed separately. The scale shall be sensitive to within 0.5 per cent of the weight of the smallest unit.

X. STRENGTH TESTS

Samples. 17. Five full-size dry tile shall be used.

Speed of Testing Machine. 18. The speed of the moving head of the testing machine shall not be more than 0.05 in. per minute.

Bearing Block. 19. A spherical bearing block of proper design shall be placed on top of the test sample.

Capping. 20. (*a*) Bearing surfaces of the test samples and portions adjoining them which are liable to absorb water from the plastic capping shall be coated with one coat of shellac and allowed to dry. A quantity of plastic mortar made of a mixture of three parts (by volume) of portland cement and one part of unretarded gypsum (plaster of Paris) mixed with sufficient water to spread evenly shall be placed on a plain surface which has been coated with oil, and allowed to harden sufficiently to bear the weight of the tile. The surface to be capped shall be placed on this mortar, and while holding the specimen so that its axis is at right angles to the capping surface it shall be given a single firm pressure.

(*b*) The average thickness of the cap after the extruded plaster has been removed and the edges trued shall not be more than $\frac{1}{8}$ in.

Patching of caps after setting shall not be permitted. Imperfect caps shall be removed and replaced with new ones.

(*c*) Where time is not available for aging the cement-gypsum cap, a cap of neat gypsum may be used, although the resulting tile strength will generally be lower than with the cement-gypsum cap. Any other method of capping which produces equally satisfactory results may be used.

Time of Testing. 21. When the cement-gypsum cap is used it shall age at least three days before the tile is tested. Where the neat gypsum cap is used the tile may be tested as soon as the plaster has been well set, but not sooner than one hour after the sample has been capped.

Position of Tile. 22. In the tests, the tile shall be loaded in the direction in which they receive the principal stress in the structure.

XI. ABSORPTION TESTS

Selection of Test Samples. 23. The samples shall consist of five tile or three representative pieces from each of these five tile. If small pieces are used two shall be taken from the shell and one from an interior web, the weight of each piece to be not less than 227 g. (½ lb.). The samples shall have had their rough edges or loose particles ground off and be free from cracks from the failure of the tile in compression, where taken from tile which have been subjected to strength tests.

Marking Test Samples. 24. Each piece shall be marked so that it may be identified at any time with the tile from which it was taken. Markings which do not cover more than 5 per cent of the total superficial area of the piece shall be used.

Drying the Test Samples. 25. Preparatory to the absorption tests all samples shall be dried to constant weight in a drier or oven at a temperature of not less than 100° C. (212° F.).

Accuracy of Weighings. 26. The balance used shall be sensitive to within 0.2 per cent of the weight of the smallest unit or piece tested.

Saturation of Samples. 27. After obtaining the dry weight of the samples they shall be immersed in soft, distilled or rain water, raised to the boiling point and boiled continuously for one hour, and then allowed to cool in water to room temperature.

Obtaining Saturated Weights. 28. After saturation, the sample shall be removed from the water and allowed to drain for not more than one minute. The superficial water shall be removed with a damp cloth, after which they shall be weighed immediately.

Calculating and Reporting Results. 29. The test results shall be calculated as percentages of the initial dry weight, carried to the nearest first decimal place. The results shall be reported separately for each tile, with the average for the five tile.

TENTATIVE SPECIFICATIONS
FOR
FIRE TESTS OF BUILDING CONSTRUCTION AND MATERIALS[1]

Serial Designation: C 19 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Prepared by the Sectional Committee on Fire Test Specifications, under the joint sponsorship of the U. S. Bureau of Standards, the A.E.S.C. Fire Protection Group and the American Society for Testing Materials, functioning under the procedure of the American Engineering Standards Committee.

These specifications were approved November 8, 1926,
As "Tentative American Standard" by the
American Engineering Standards Committee.

The performance of walls, columns, floors and other building members under fire exposure conditions is an item of major importance in securing constructions which are safe and which are not a menace to neighboring structures nor to the public. Recognition of this is registered in the codes of many authorities, municipal and other. It is important to secure balance of the many units in a single building, and of buildings of like character and use in a community; and also to promote uniformity in requirements of various authorities throughout the country. To do this it is necessary that the fire-resistive properties of materials and assemblies be measured and specified according to a common standard expressed in terms which are applicable alike to a wide variety of materials, situations and conditions of exposure.

Such a standard is found in the specifications which follow. They prescribe a standard exposing fire of controlled extent and severity. Performance is defined as the period of resistance to standard exposure elapsing before the first critical point in behavior is observed. Results are reported in units in which field exposures can be judged and expressed.

The specifications may be cited as the "Standard Fire Test Specification" and the performance or exposure shall be expressed as "2-hour," "6-hour," "½-hour," etc.

When a factor of safety exceeding that inherent in the test conditions is desired, a proportional increase should be made in the specified time-classification period.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. P. Miller, Secretary of Committee C-5 on Fire Tests of Materials and Construction, 342 Madison Ave., New York City.

These specifications are in effect a revision of the Standard Specifications for Fire Tests of Materials and Construction. The Standard Specifications, which were last published under the Serial Designation: C 19 – 18, have accordingly been withdrawn.

Classifications of assemblies involving combustibles in sufficient quantity or so arranged as to continue burning after the derived time period shall be designated by the term "combustible" after the period assigned.

Scope.

1. (*a*) The test methods are applicable to assemblies of masonry units and to composite assemblies of structural materials for buildings, including bearing and other walls and partitions, columns, girders, beams and slabs and composite slab and beam assemblies for floors and roofs. They are also applicable to other assemblies and structural units which constitute permanent integral parts of a finished building.

(*b*) It is the intent that classifications shall register performance during the period of exposure and shall not be construed as having determined suitability for use after fire exposure.

I. CONTROL OF FIRE TESTS

Time Temperature Curve.

2. The conduct of fire tests of materials and construction shall be controlled by the standard time-temperature curve shown in Fig. 1. The points on the curve which determine its character are:

1000° F.	(approximately	538° C.)	at 5 minutes
1300° F.	("	704° C.)	" 10 "
1550° F.	("	843° C.)	" 30 "
1700° F.	("	927° C.)	" 1 hour
1850° F.	("	1010° C.)	" 2 hours
2000° F.	("	1093° C.)	" 4 "
2300° F.	("	1260° C.)	" 8 "

Determination of Furnace Temperatures.

3. (*a*) The temperature fixed by the curve shall be deemed to be the average temperature obtained from the readings of several thermocouples (not less than three) symmetrically disposed and distributed to show the temperature near all parts of the sample, the thermocouples being enclosed in sealed porcelain tubes $\frac{3}{4}$ in. in outside diameter and of $\frac{1}{8}$-in. wall thickness. The exposed length of the porcelain tube and couple in the furnace chamber shall be not less than 12 in. Other types of protecting tubes or pyrometers may be used that under test conditions give the same indications as the above standard within the limit of accuracy that applies for furnace-temperature measurements. For greater difference of design and size the time-temperature curve followed shall be modified to give an exposure equal to that obtained by using the standard pyrometer and curve above described.

(*b*) The temperatures shall be read at intervals not exceeding 5 minutes during the first hour, and thereafter the intervals may be increased to not more than 15 minutes.

(*c*) The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results from the pyrometer readings, is within 15 per cent of the corresponding area under the standard time-temperature curve shown in Fig. 1 for fire tests of one hour or less duration; within 10 per cent for those over one hour and not more than two hours; and within 5 per cent for tests exceeding two hours in duration.

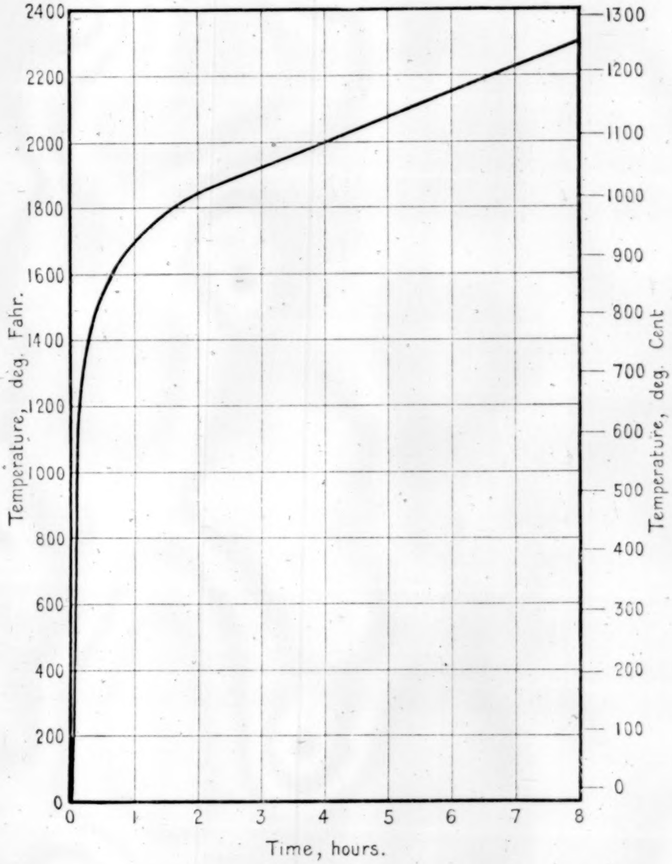

FIG. 1.—Time Temperature Curve.

Determination of Temperatures of Unexposed Surfaces of Floors, Walls and Partitions.

4. (*a*) Temperatures at unexposed surfaces shall be measured with thermocouples or thermometers[1] placed under oven dry asbestos fire felt pads 6 in. square, 0.4 in. thick and weighing not less than 1.0 lb. per sq. ft. nor more than 1.4 lb. per sq. ft. The wire leads of the thermocouple or the stem of the thermometer shall have an

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[1] Under certain conditions it may be unsafe or impracticable to use thermometers.

immersion under the pad and be in contact with the unexposed surface for not less than 3½ in. The hot junction of the thermocouple or the bulb of the thermometer shall be placed approximately under the center of the pad. The outside diameter of protecting tubes of glass, clay or porcelain, and of thermometer stems, shall not be more than $\frac{5}{16}$ in. The pad shall be held firmly against the surface, and shall fit closely about the thermocouples or thermometer stems. Thermometers shall be of the partial-immersion type, with a length of stem, between the end of the bulb and the immersion mark, of 3 in. The wires for the thermocouple in the length covered by the pad shall not be heavier than No. 18 B. & S. gage (0.04 in.) and shall be electrically insulated with heat- and moisture-resistant coatings.

(*b*) The temperature readings shall be taken at not less than five points on the surface, one of which shall be approximately at the center, and four at approximately the centers of the quarter sections. If additional points are used they shall be symmetrically disposed about the center, with no location nearer than 1½ times the thickness of the construction, or nearer than 12 in., to the edges. None shall be located opposite or on top of beams, girders, pilasters or other structural members.

(*c*) Temperature readings shall be taken at intervals not exceeding 15 minutes until a reading exceeding 212° F. (100° C.) has been obtained at any one point. Thereafter the readings may be taken more frequently at the discretion of the testing body, but the intervals need not be less than 5 minutes.

(*d*) Where the Conditions of Acceptance place a limitation on the rise of temperature of the unexposed surface, the temperature end point of the fire endurance period shall be determined by the average of the measurements taken at individual points; excepting that if a temperature rise 30 per cent in excess of the specified limit occurs at any one of these points, the remainder shall be ignored and the fire endurance period judged as ended.

II. CLASSIFICATION AS DETERMINED BY TEST

Report of Results.

5. Results shall be reported in accordance with the performance in the tests prescribed in these specifications. They shall be expressed in time periods of resistance, as for example 4-hour, ½-hour, etc.

III. TEST STRUCTURES

Test Structures.

6. (*a*) The test structure may be located at any place where all the necessary facilities for properly conducting the test are provided.

(*b*) Entire freedom is left to each investigator in the design of his test structure and the nature and use of fuel, provided the test requirements are met.

IV. TEST SAMPLES

Test Samples.

7. The test sample shall be truly representative of the construction for which classification is desired, and shall be built under conditions representative of those obtaining as practically applied in building construction. The physical properties of the materials and/or ingredients used in the test sample shall be determined and recorded.

V. CONDUCT OF FIRE TESTS

Fire Endurance Test.

8. The fire endurance test on the sample with its applied load, if any, shall be continued until failure occurs, or until it has withstood the test conditions for a period equal to that herein specified in the Conditions of Acceptance for the given type of construction.

TABLE I.

Parts of Structure	Resistance Period	Water Pressure at Nozzle, lb. per sq. in.	Duration of Application, minutes per 100 sq. ft. exposed area
Floors and Roofs	8 hours and over	45	6
	4 hours and over if less than 8 hours	45	5
	2 hours and over if less than 4 hours	45	$2\frac{1}{2}$
	1 hour and over if less than 2 hours	30	$1\frac{1}{2}$
	Less than 1 hour	30	1
Walls and Partitions	8 hours and over	45	6
	4 hours and over if less than 8 hours	45	5
	2 hours and over if less than 4 hours	30	$2\frac{1}{2}$
	1 hour and over if less than 2 hours	30	$1\frac{1}{2}$
	Less than 1 hour	30	1

Fire Stream Test.

9. (*a*) Where required by the Conditions of Acceptance, a duplicate sample shall be subjected to a fire exposure test for a period equal to one-half of that indicated as the resistance period in the fire endurance test, but not for more than one hour, immediately after which the sample shall be subjected to the impact, erosion and cooling effects of a fire hose stream directed first at the middle and then at all parts of the exposed face, changes in direction being made slowly.

Exemption.

(*b*) The fire hose stream test shall not be required in the case of constructions having a resistance period, indicated in the fire endurance test, of one-half hour or less.

Optional Program.

(*c*) The submitter may elect, with the advice and consent of the testing body, to have the fire hose stream test made on the sample subjected to the fire endurance test and immediately following the expiration of the fire endurance test; provided, that the testing body reserves the right to decide that a fire hose stream test should be made on a duplicate sample as specified in Paragraph (*a*).

Stream Equipment and Details. (*d*) The stream shall be delivered through 2½-in. hose, discharging through a National Standard Playpipe of corresponding size equipped with a 1⅛-in. discharge tip of the standard taper smooth-bore pattern without shoulder at the orifice. The water pressure and duration of application shall be as specified in Table I.

Nozzle Distance. (*e*) The nozzle orifice shall be 20 ft. from the center of the exposed surface of the test sample if the nozzle is so located that when directed at the center its axis is normal to the surface of the test sample. If otherwise located its distance from the center shall be less than 20 ft. by an amount equal to 1 ft. for each 10 deg. of deviation from the normal.

Time of Testing. 10. The material or construction shall not be tested until a large proportion of its final strength has been attained, and, if it contains free water, until the excess has been given off; this will usually require about 30 days time under favorable drying conditions. Where this cannot be attained within 40 days, artificial drying with air temperature not exceeding 100° F. (38° C.) shall be used.

VI. TESTS OF BEARING WALLS AND PARTITIONS

Size of Sample. 11. The area exposed to fire shall be not less than 100 sq. ft., with neither dimension less than 9 ft. The test specimen shall not be restrained on its vertical edges.

Loading. 12. During the fire endurance and fire and fire stream tests the construction shall be loaded in a manner calculated to develop theoretically as nearly as practicable the working stresses contemplated by the design.

Conditions of Acceptance. 13. The test shall not be regarded as successful unless the following conditions are met:

(*a*) The wall or partition shall have sustained the applied load during the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

(*b*) The wall or partition shall have sustained the applied load during the fire and fire stream test as specified in Section 9, without passage of flame, stream or gases hot enough to ignite cotton waste, and after cooling but within 72 hours after its completion shall sustain a total load equal to the dead load plus twice the superimposed load specified above.

(*c*) The fire-stopping, if any, shall have functioned to prevent passage of fire for a period equal to that for which classification is desired.

(*d*) Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250° F. (139° C.) above its initial temperature.

VII. TESTS OF NON-BEARING WALLS AND PARTITIONS

Size of Sample.

14. The area exposed to fire shall be not less than 100 sq. ft. with neither dimension less than 9 ft. The test specimen shall be restrained on all four edges.

Conditions of Acceptance.

15. The test shall not be regarded as successful unless the following conditions are met:

(*a*) The wall or partition shall have withstood the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

(*b*) The wall or partition shall have withstood the fire and fire stream test as specified in Section 9, without passage of flame, stream or gases hot enough to ignite cotton waste.

(*c*) The fire-stopping, if any, shall have functioned to prevent passage of fire for a period equal to that for which classification is desired.

(*d*) Transmission of heat through the wall or partition during the fire endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250° F. (139° C.) above its initial temperature.

VIII. TESTS OF COLUMNS

Size of Sample.

16. The length of the column exposed to fire shall, when practicable, approximate the maximum clear length contemplated by the design, and for building columns shall not be less than 9 ft. The contemplated details of connections, and their protection if any, shall be applied according to the methods of acceptable field practice.

Loading.

17. (*a*) During the fire endurance test the column shall be loaded in a manner calculated to develop theoretically as nearly as practicable the working stresses contemplated by the design. Provision shall be made for transmitting the load to the exposed portion of the column without unduly increasing the effective column length.

(*b*) If the submitter and the testing body jointly so decide, the column may be subjected to $1\frac{3}{4}$ times its designed working load before the fire endurance test is undertaken. The fact that such a test has been made shall not be construed as having had a deleterious effect on the fire endurance test performance.

Condition of Acceptance.

18. The test shall not be regarded as successful unless the column shall have sustained the applied load during the fire endurance test for a period equal to that for which classification is desired.

IX. TESTS OF FLOORS AND ROOFS

(The following contemplates application of fire exposure to the under side of constructions, and omission from the upper surface of all units which are not essential to the constructions. Specifications and test procedure with fire applied to the upper side have not been developed.)

Size of Sample.

19. The area exposed to fire shall be not less than 180 sq. ft. with neither dimension less than 12 ft. Beams or girders if a part of the construction under test shall lie within the combustion chamber and have a clearance of not less than 8 in. from its walls.

Loading.

20. During the fire endurance and fire and fire stream tests the construction shall be loaded in a manner calculated to develop theoretically as nearly as practicable the working stresses in each member contemplated by the design.

Conditions of Acceptance.

21. The test shall not be regarded as successful unless the following conditions are met:

(*a*) The construction shall have sustained the applied load during the fire endurance test without passage of flame or gases hot enough to ignite cotton waste, for a period equal to that for which classification is desired.

(*b*) The construction shall have sustained the applied load during the fire and fire stream test as specified in Section 9, without passage of flame, stream or gases hot enough to ignite cotton waste, and after cooling but within 72 hours after its completion shall sustain a total load equal to the dead load plus twice the superimposed load specified above.

(*c*) Transmission of heat through the construction during the fire endurance test shall not have been such as to raise the temperature on its unexposed surface more than 250° F. (139° C.) above its initial temperature.

X. TESTS OF FINISH FOR WALLS, PARTITIONS AND CEILINGS

Character of Sample.

22. The test panel shall be a wall, partition or floor.

(*a*) Test panels carrying interior wall and partition finish shall be finished on both faces with the finish which is the subject of the test; excepting that with the advice or consent of the testing body this provision may be waived with respect to panels of solid or masonry construction.

(*b*) Test panels carrying exterior wall finish on the exposed face shall be finished on the unexposed face with an interior wall finish judged by the testing body to be suitable for purposes of the test; excepting that with the advice or consent of the testing body this provision may be waived with respect to panels of solid or masonry construction.

(*c*) Test panels carrying ceiling finish shall be finished on the upper face with a flooring judged by the testing body to be suitable for purposes of the test; excepting that with the advice or consent of the testing body this provision may be waived with respect to panels of solid or masonry construction.

Size of Sample.

23. The area exposed to fire shall be for tests of wall and partition finish, not less than 100 sq. ft., with neither dimension less than 9 ft.; for tests of ceiling finish, not less than 180 sq. ft., with neither dimension less than 12 ft.

Conditions of Acceptance.

24. The test shall not be regarded as successful unless the following conditions are met:

(*a*) The finish shall have withstood the fire endurance test without developing openings capable of passing flame or hot gases, for a period equal to that for which classification is desired.

(*b*) The finish shall have withstood the fire and fire stream test as prescribed respectively for floors, walls and partitions as specified in Section 9, without developing openings capable of passing flame, hot gases or stream.

(*c*) Transmission of heat through the finish during the fire endurance test shall not have been such as to raise the temperatures at its contact with the structural members of the test panel or elsewhere on its unexposed surface more than 250° F. (139° C.) above the initial temperatures at these points.

TENTATIVE METHODS OF CHEMICAL ANALYSIS OF LIMESTONE, QUICKLIME AND HYDRATED LIME.[1]

Serial Designation: C 25 – 26 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1919; REVISED, 1921, 1922, 1925, 1926.

TREATMENT OF SAMPLE

Treatment of Sample.

The sample, taken and prepared in accordance with the requirements of the particular specifications of the Society applicable to the material shall be treated as follows:

Weigh out 0.5 g. of the substance and, if a limestone or hydrated lime, ignite in a covered platinum crucible in an electric muffle (Note 1) for 15 minutes, or longer if the heat is not powerful enough to effect complete decomposition within that time. Transfer to an evaporating dish, preferably of platinum (Note 2) for the sake of celerity in evaporation, mix to a thin slurry with distilled water, add 5 to 10 cc. of HCl (sp. gr. 1.20) and digest with aid of gentle heat and agitation until solution is complete. Solution may be aided and the time shortened by light pressure with the flattened end of a glass rod upon resistant lumps. Then evaporate the solution to dryness, so far as this may be possible on the water bath.

DETERMINATION OF SILICA AND INSOLUBLE MATTER, INCLUDING SILICA.

Silica and Insoluble Matter.

When dry or nearly so, place the dish and its contents in an air bath or (covered) on a platinum triangle resting on a hot plate and, if it is a high calcium limestone that is under treatment, heat for one hour at 200° C.; if a high magnesian stone is under treatment the temperature should not exceed 120° C. Drench the cooled mass with HCl (sp. gr. 1.20) and allow to stand for a few minutes. Add an equal volume of water, cover the dish and place on the water bath for

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. **J. S. Elwell**, Secretary of Committee C-7 on Lime, National Lime Association, 918 G St., N. W., Washington, D. C.

Bulletin 700, U. S. Geological Survey, should be used as a reference book in connection with these methods, especially when very exact and detailed analyses are desired. Blank determinations should be made on all reagents, and corrections applied when called for.

10 minutes (Note 3). Separate the silica by filtration on a filter of suitable size. Wash thoroughly with dilute HCl and then wash twice with cold water.

Evaporate the filtrate to dryness. Extract the residue with HCl as before but allowing only a few minutes time. Filter this solution through a second and smaller paper.

Transfer, wet, the papers containing the separated residue to a weighed platinum crucible. Char carefully without allowing the paper to inflame, and ignite to constant weight in an electric muffle, and weigh (Note 1). The increase in weight represents the insoluble and siliceous matter and is reported as insoluble matter, including silica.

Silica:

To determine the amount of silica (SiO_2), treat the "insoluble matter, including silica," in the crucible with 5 cc. of water, 5 cc. of HF and one or two drops of H_2SO_4,[1] and evaporate to dryness. Heat the residue for 2 or 3 minutes in an electric muffle and again weigh. The difference between this weight and that previously obtained gives the weight of "silica" (SiO_2) (Note 4).

If the silica is determined by volatilization with HF, the residue in the crucible is fused with a little Na_2CO_3, and the cooled melt is dissolved in diluted HCl and the solution added to the filtrate from the second evaporation for "insoluble matter, including silica." If the "insoluble matter, including silica," is reported as such and no HF treatment is given, the "insoluble matter, including silica," is not fused or further treated.

Insoluble Matter, Excluding Silica:

The difference between the weight of "insoluble matter, including silica," and "silica" represents the "insoluble matter, exclusive of silica."

DETERMINATION OF TOTAL IRON AND ALUMINUM.

Iron and Alumina.

To the HCl solution from the determination of silica add a few drops of bromine water or HNO_3 and boil the solution until all trace of bromine or chlorine is gone. Then add HCl, if not already present, sufficient to insure a total volume of 10 to 15 cc. of HCl (sp. gr. 1.20).[2] Add a few drops of methyl red solution and after diluting to 200 to 250 cc. heat the liquid to boiling. Neutralize by means of NH_4OH (dilute towards the end) until the color of the liquid changes to a distinct yellow. Boil for one or two minutes, allow to settle, filter and wash the precipitate at once two or three times with hot NH_4Cl (2-per-cent) solution and suck dry.[1]

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[1] See *Bulletin 700*, U. S. Geological Survey, p. 103.

[2] See *Bulletin 700*, U. S. Geological Survey, p. 258.

Set the filtrate aside. Dissolve any precipitate from the paper in hot, dilute HCl, the solution passing into the beaker in which the precipitation was made and wash the paper thoroughly with hot water. Boil the solution to expel any trace of chlorine and again precipitate the hydroxides with NH_4OH as described above. Ignite the precipitate, moist (Note 1), in a weighed platinum crucible, cool and weigh as Al_2O_3 and Fe_2O_3 (Note 6).

DETERMINATION OF TOTAL IRON.

Total Iron.

Fuse the combined iron and aluminum oxides (Note 7) in a platinum crucible at a very low temperature with 3 to 4 g. of $K_2S_2O_7$ or better $Na_2S_2O_7$ (Note 8). Take up the melt with so much dilute H_2SO_4 that there shall be not less than 5 g. absolute acid and enough water to effect solution on heating. Evaporate the solution and eventually heat until acid fumes come off copiously. After cooling and redissolving in water, filter out the small amount of silica, wash, ignite, weigh and correct by HF and H_2SO_4 (Note 9). Add the weight so corrected to the weight of silica previously found and deduct from the gross weight of the oxides of iron and aluminum.

Reduce the filtrate by zinc (Note 10). Titrate with $KMnO_4$ using a N/20 solution.

DETERMINATION OF ALUMINUM.

Aluminum.

Subtract the calculated weight of Fe_2O_3 obtained by the method described above from the weight of $Fe_2O_3 + Al_2O_3$. Report the remainder as Al_2O_3. In case phosphorus is determined, calculate it to P_2O_5 and deduct also.

DETERMINATION OF TOTAL IRON.

ALTERNATIVE METHOD (Note 7).

Total Iron, Alternative.

Dissolve 2 to 5 g. (depending upon the amount of iron present) of the properly prepared sample in HCl and evaporate rapidly to dryness. Treat the residue with water and HCl, filter off the silica and wash several times with hot water. Precipitate the iron in a boiling solution with fixed alkali, allow to settle, filter and wash free of chlorides, using hot water. Dissolve in dilute H_2SO_4.

Ignite the insoluble matter from the evaporated hydrochloric acid solution in a platinum crucible. Treat with H_2SO_4 and HF and heat until fumes of H_2SO_4 appear. Bring the residue into solution with the addition of a few drops more of H_2SO_4 and combine the solution with that of the bulk of the iron. Reduce this solution by zinc and titrate the iron with $KMnO_4$ in the usual manner.

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[1] See *Bulletin 700*, U. S. Geological Survey, p. 107.

DETERMINATION OF CALCIUM.

(Note 11.)

(*a*) *Gravimetric Method.*

Calcium, Gravimetric.

Add a few drops of NH_4OH to the combined filtrate from the R_2O_3 precipitate, and bring the solution to boiling. To the boiling solution add 35 cc. of a saturated solution of $(NH_4)_2C_2O_4$, and continue the boiling until the precipitated CaC_2O_4 assumes a granular form; then allow it to stand 20 minutes, or until the precipitate has settled and the supernatent liquid is clear, filter and wash thoroughly with boiling water (Note 12). Place the wet filter and precipitate in a platinum crucible, and burn off the paper over the small flame of a Bunsen burner, or in a muffle. Ignite the residue, dissolve in hot dilute HCl, and make up the volume of the solution to 100 cc. with water. Add NH_4OH in slight excess and boil the liquid. If a small amount of $Al_2(OH)_6$ separates, filter it out, wash with NH_4Cl (2-percent solution), ignite, weigh and add this weight to that found in the first determination. Then reprecipitate the lime by $(NH_4)_2C_2O_4$, allow to stand until settled, filter, wash thoroughly with boiling water (Note 12) and weigh as calcium oxide after ignition to constant weight in a covered platinum crucible.

(*b*) *Volumetric Method.* (Note 13.)

Calcium, Volumetric.

Make the filtrate from the iron and alumina precipitate alkaline with NH_4OH, boil, and add 35 cc. of a boiling saturated solution of $(NH_4)_2C_2O_4$. Stir vigorously and allow to stand until the precipitate has settled, filter on an 11-cm. paper, and wash ten times with hot water (Note 14). Transfer the paper and precipitate to the beaker in which the precipitation was made, spreading the paper out against the upper portion of the beaker. Wash the precipitate from the paper with a jet of hot water, fold the paper and leave it adhering to the upper portion of the beaker. Add to the contents of the beaker 50 cc. of dilute H_2SO_4 (1:10), dilute to a volume of 250 cc. with hot water and heat to a temperature of 80 to 90° C. Titrate with the standard $KMnO_4$ solution[1] until the pink end point is obtained. Now drop the folded filter paper (which has been adhering to the side of the beaker) into the liquid; the pink color of the latter will be discharged. Finish the titration by adding $KMnO_4$, a drop at a time, until the pink end point is again obtained. A Gooch crucible may be used instead of filter paper. From the total quantity of standard $KMnO_4$ solution used, calculate the percentage of calcium oxide.

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[1] See directions for preparing this solution.

DETERMINATION OF STRONTIUM.

Strontium. Transfer the weighed oxides obtained in the gravimetric determination of calcium to a small flask of 20-cc. capacity and dissolve in HNO_3. Evaporate to dryness and heat at 150 to 160° C. Treat the thoroughly dried nitrates with as little (rarely over 2 cc.) of a mixture of equal parts of absolute alcohol and ether as may be needed to dissolve the calcium salt, solution being hastened by occasional gentle agitation. After standing over night in the corked flask collect the insoluble matter on the smallest possible filter and wash with more of the above mixture of alcohol and ether. After drying, pass a few cubic centimeters of hot water through the filter, on which may remain a few tenths of a milligram of residue, which does not usually contain any lime or other alkaline earth and whose weight is therefore to be deducted from that of the lime, unless it can be shown that it is derived from the glass of the little flask in which the nitrates of calcium and strontium were evaporated. To the solution of strontium nitrate in a small beaker add a few drops of H_2SO_4 and then its volume of alcohol, whereby the strontium is precipitated as sulfate. After twelve hours, filter on a small filter paper and wash the residue with 50-per-cent alcohol. Ignite at a low temperature, moisten with dilute H_2SO_4, evaporate, again ignite and weigh as strontium sulfate. Test the sulfate spectroscopically as to freedom from calcium and barium.

Calculate the weight of strontium oxide and deduct from the weight of calcium oxide obtained as above.

DETERMINATION OF MAGNESIUM.

Magnesium. Acidify the combined filtrates from the calcium precipitates with HCl and concentrate on the water bath to about 150 cc., and heat to boiling. To the boiling solution add 10 cc. of a saturated solution of $Na(NH_4)HPO_4$ and continue the boiling for several minutes. Then cool to room temperature, and add NH_4OH drop by drop with constant stirring until the crystallin ammonium-magnesium orthophosphate begins to form and then in moderate excess, the stirring being continued for several minutes. Allow the liquid to stand in a cool atmosphere for from 12 to 48 hours (Note 15) and filter.

Dissolve the precipitate in hot dilute HCl, make up the solution with water to about 100 cc., add 1 cc. of the saturated solution of $Na(NH_4)HPO_4$ and NH_4OH drop by drop with constant stirring until the precipitate is again formed as above described and the ammonia is present in moderate excess. Then allow it to stand in a cool atmosphere for from 12 to 48 hours (Note 15), filter on paper or a Gooch crucible, wash with dilute NH_4OH containing NH_4NO_3 (Note 16), ignite (Note 1), cool, and weigh as $Mg_2P_2O_7$ (Note 17).

DETERMINATION OF TOTAL VOLATILE MATTER.

(LOSS ON IGNITION.)

Volatile Matter.

Place 1 g. of the properly prepared sample (Note 18) in a weighed platinum crucible, cover with the lid and heat gently for 5 minutes (Note 1), gradually increasing the temperature to the maximum of the muffle, and maintain at this temperature until constant weight is obtained (usually about 15 minutes).

DETERMINATION OF MECHANICAL MOISTURE

(LIMESTONE ONLY.) (Note 19.)

Mechanical Moisture.

Weigh 1 g. of the properly prepared sample in a tared, wide, low-form, flat-bottomed weighing bottle. Heat uncovered in a ventilated drying oven at 120° C. for two hours. Quickly stopper and cool in a desiccator. Lift the stopper momentarily just before weighing and weigh. The use of a similar weighing bottle as a counterpoise carried through all of the operations is a desirable procedure. The loss in weight represents "Mechanical Moisture" or "Hydroscopic Water" at 120° C.

DETERMINATION OF CARBON DIOXIDE.

Carbon Dioxide.

Carbon dioxide is to be determined upon the properly prepared sample according to the method given in U. S. Geological Survey Bulletin No. 700, p. 217. An illustration showing the arrangement of the component parts of the necessary apparatus is shown on p. 218 of that Bulletin.

With limestone, use a 0.5 g. sample; with burned lime, hydrated lime, etc., use a 5-g. sample.

Boil the weighed sample with dilute HCl in a small Erlenmeyer flask attached to an upwardly inclined condenser, whence, after passing through a drying system—calcium chloride, anhydrous copper sulfate to retain hydrogen sulfide from decomposable sulfides and any HCl that may pass over, then calcium chloride again—the carbon dioxide is caught by absorption tubes filled with soda-lime followed by calcium chloride. Of course, arrangement is made for a current of air free from CO_2 with which to sweep out the apparatus before and after the experiment, and for a slow current during its continuance.

The results are very accurate and the determination can be quickly carried out.

The manipulations are as follows: Pour hot water upon the powder in the flask fitted with a separatory funnel and delivery tube; attach this to the condenser, and force a current of air free from CO_2 through the whole system, except the weighed absorption tubes, until the original air has been displaced, the observation bulbs (containing H_2SO_4 to show the rate of gas flow) being attached directly to the drying system. Then close the stop-cock in the separatory funnel, half fill the latter with HCl (1:1), replace the rubber stopper of the funnel, insert the absorption tubes between the drying system and the observation bulbs, and allow the acid to flow into the flask, slowly if there is much carbon dioxide, rapidly if there is but little. When effervescence diminishes in the former case, at once in the latter, light the burner under the flask and start the flow of water through the condenser. Keep the flame low, so as to secure steady but quiet ebullition, and do not interrupt the air current although it should be reduced to a slow rate. With much carbon dioxide the rate of absorption is very readily noted by holding the hand to the soda-lime tubes, which become hot or warm when absorption is taking place. Sufficient time having elapsed (Note 20), extinguish the flame, and increase the air current. When cool, disconnect the soda-lime tubes from the apparatus and allow to stand in the balance case until two weights taken 30 minutes apart agree within 0.5 mg.

The soda lime for use in this determination must be porous, not hard and unabsorptive like that sometimes used for the combustion of nitrogenous organic substances.

DETERMINATION OF SULFURIC ANHYDRIDE.

Sulfuric Anhydride.

Place 2 g. of the properly prepared sample in a small, dry beaker and stir it up with 10 cc. of cold water until all lumps are broken up and the lighter particles are in suspension. Add 15 cc. of dilute HCl (1:1) and heat until solution is complete. Filter through a small paper and wash the residue thoroughly with hot water. Dilute the filtrate to 250 cc., heat to boiling, and add 10 cc. of a boiling 10-per-cent solution of barium chloride drop by drop with constant stirring. Stir well and allow to stand over night. Filter, wash with boiling water, ignite and weigh as $BaSO_4$.

DETERMINATION OF TOTAL SULFUR.

Total Sulfur.

Weigh 1 g. of a properly prepared sample. Add approximately 0.5 g. of sodium carbonate. Mix thoroughly in a porcelain crucible and heat gently until sintered. Then ignite for 15 minutes at a temperature of approximately 1000° C., taking care to allow access of air to the contents of the crucible. Cool and place the crucible in a 250-cc. beaker and cover with hot water. Add 10 cc. of bromine water, then 30 cc. of hydrochloric acid (1:1) and boil until solution is complete and all bromine has been expelled. Remove the crucible, washing it with water. Add a few drops of methyl red, and render the solution alkaline with ammonium hydroxide (1:1). Boil the solution for 1 or 2 minutes, filter and wash with hot water. To the filtrate add 5 cc. of hydrochloric acid (1:1), adjust the volume to about 200 cc., bring the solution to boiling and while boiling add 10 cc. of hot 10-per-cent barium chloride solution. Allow to stand over night. Filter, wash with hot water, ignite and weigh as $BaSO_4$.

NOTE.—It is usually desirable to make a fusion in a platinum crucible. However, it has been found that with limestones very high in impurities, when the fusion is made in a muffle, the damage to platinum ware is considerable. It has been proved that the use of porcelain crucibles introduces no appreciable error.

DETERMINATION OF PHOSPHORUS.

Phosphorus.

Dissolve 10 g. of the sample in 80 cc. of dilute HNO_3 (1:1), filter, and wash the residue with hot water. Ignite, and fuse the residue with a little Na_2CO_3, cool the melt and add its nitric acid solution to the main filtrate. (Note 21.)

In case the rock is rather argillaceous, mix the powder with half its weight of Na_2CO_3 and blast strongly. Dissolve the cooled melt in HNO_3 and evaporate to dryness. Take up the dry residue with dilute HNO_3 (1:2), filter and wash the residue with hot water. Ignite the residue in platinum, and evaporate with HF and HNO_3. Finally, evaporate twice with HNO_3 alone to expel all fluorine, dissolve the residue in HNO_3 and add the solution to the main filtrate. (Note 21.)

Oxidize the nitric acid solution by boiling with 10 cc. of 1.5-per-cent $KMnO_4$ solution until manganese dioxide is precipitated. Dissolve the oxide by addition of H_2SO_3 or a sulfite free from phosphorus and boil to expel the oxides of nitrogen and sulfur. Neutralize the HNO_3 with NH_4OH and then add 1 cc. of HNO_3 (sp. gr. 1.42) for every 100 cc. of solution. Bring the solution to a temperature of 40° C., add ammonium molybdate solution[1] and shake for 10 minutes. Allow to stand at a temperature of not over 40° C. for 1 to 12 hours. Filter and wash 10 times with a 1-per-cent KNO_3 solution. Return the precipitate to the precipitating vessel, add a measured excess of N/10 NaOH and 25 cc. of water free from CO_2 and shake or stir until the precipitate is dissolved. Dilute to 100 to 200 cc. with water free from CO_2, add 3 drops of 0.2-per-cent phenolphthalein solution, and discharge the pink color with standard acid. Finish the titration by adding standard alkali until the reappearance of the pink color. The alkali solution should be free from carbonate and be standardized against the Bureau of Standards' standard benzoic acid.[2] The ratio of phosphorus to NaOH should be considered as 1 : 23 in calculating results. (Note 22.)

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[1] See Blair, "The Chemical Analysis of Iron," 8th Edition, p. 92.

[2] See *Journal*, Am. Chem. Soc., Vol. 34, p. 1027 (1912), and Vol. 35, p. 1309 (1913).

DETERMINATION OF MANGANESE.

Manganese. Dissolve 10 g. of the sample in 100 cc. of dilute HNO_3 (1 : 1), filter and wash the residue with hot water. Ignite the residue in platinum, fuse with a little Na_2CO_3 and add the nitric acid solution of the melt to the main filtrate.

Dilute the solution to 150 cc. and add 0.5 g. of sodium bismuthate (Note 23). Heat for a few minutes, or until the pink color has disappeared and dioxide has precipitated. If manganese dioxide does not precipitate add more bismuthate. Clear the solution by adding a few drops of a saturated solution of sodium bisulfite or other suitable reducing agent free from chlorides, and boil to expel all oxides of nitrogen and sulphur. Cool to 15° C., add an excess of sodium bismuthate, agitate and let stand for a few minutes. Add 50 cc. of 3-per-cent HNO_3 and filter through asbestos. Wash with 3-per-cent HNO_3 until the washings run through colorless. Add a measured excess of a standard $FeSO_4$ solution and titrate back with a standard $KMnO_4$ solution of which the strength has been determined by means of the Bureau of Standards sodium oxalate. (Note 24.)

DETERMINATION OF FERROUS IRON SOLUBLE IN SULFURIC ACID.

Ferrous Iron. In limestones, the presence of carbonaceous matter renders the exact or even approximate determination of ferrous iron often impossible. Nevertheless, even in its presence acceptable results are sometimes obtainable if there is not much of such matter and if it does not give with acid a colored solution. Occasionally limestones show films of manganese peroxide, which likewise interferes with the determination.

(*a*) *In Absence of Carbonaceous Matter.*

The powder, one to several grams, is introduced into a stout flask of about 200 to 250-cc. capacity and boiled with a little water till all air is expelled. While still boiling, dilute H_2SO_4 is added, a little at a time, till effervescence ceases, and then a further amount. Calcium sulfate precipitates, but the iron will remain in solution. The flame is then removed and a stopper tightly inserted, through which passes a small stop-cock funnel. When cool, or nearly so, cold water is poured into the funnel, the cock cautiously opened, and the water drawn into the flask, more water being poured into the funnel as fast as it empties, till the solution amounts to 100 to 150 cc. Such precaution to exclude air is hardly necessary in most cases, however, for in presence of H_2SO_4 the oxidation of ferrous iron is exceedingly slow. It is ordinarily quite sufficient to equalize the internal and external pressures by opening the cock, removing the stopper, and pouring in cold water. The flask is then brought under a burette containing dilute $KMnO_4$ solution and the iron titrated without delay. With a carbonate which is wholly decomposable without the aid of heat, solution may be accomplished in a flask filled with CO_2, using cold acid, whereby the danger of attack of silicates is lessened if these are present. If the preference is for the $K_2Cr_2O_7$ method of titration, HCl may be used instead of H_2SO_4, in absence of manganese peroxide. In this case there is, of course, no separation of an insoluble calcium salt, a fact which renders easier the subsequent determination of the iron in any insoluble residue the rock may yield. The ferrous iron thus found is mostly, if not altogether, that existing as carbonate.[1]

(*b*) *In Presence of Carbonaceous Matter.*

Decomposition is effected in a flask by dilute H_2SO_4 in an atmosphere of CO_2. With limestones and active agitation no heat need be used, but with dolomites it will be necessary. The solution is then quickly filtered through asbestos (in an atmosphere of CO_2 if much iron is present), the residue and filter washed a few times with water, and the filtrate titrated at once with permanganate. If it is colored by organic matter, the result may be in error. As above, HCl and titration by $K_2Cr_2O_7$ may be used in absence of manganese peroxide. In either case it is important to allow the acid to act no longer than is necessary and to filter quickly. A determination of the ferrous iron in the insoluble matter is usually not worth attempting, because of the admixed organic matter.

DETERMINATION OF AVAILABLE LIME IN QUICKLIME AND HYDRATED LIME BY THE MODIFIED SCAIFE METHOD

Available Lime.

"Available lime" in quicklime or hydrated lime is that (or those) constituent (or constituents) which enters (or enter) into the reaction under the conditions of the specified method or process.

The interpretation of results obtained by the following method shall be restricted by the above definition.

Place 1.4 g. of the carefully prepared and finely ground (passing a No. 100 sieve) lime in a 400-cc. beaker, add 200 cc. of hot water, cover, heat carefully and then boil for three minutes.

Cool, wash down cover, add two drops of phenolphthalein and titrate with normal hydrochloric acid, adding the acid dropwise as rapidly as possible and stirring vigorously to avoid local excess of acid. When the pink color disappears in streaks, retard the rate of addition of acid somewhat, but continue until the pink color disappears entirely and does not reappear for 1 or 2 seconds. Note the reading and ignore the return of color.

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[1] If a determination of ferrous iron in the insoluble residue is desired, see U. S. Geological Survey *Bulletin 700*, p. 265.

Repeat the test, substituting for the 400-cc. beaker a 1-liter graduated flask, carrying a one-hole stopper fitted with a short glass tube drawn out to a point. Cool and add dropwise and with vigorous stirring 5 cc. less acid than before. Call the number of cubic centimeters used A. Grind up any small lumps with a glass rod flattened at one end, dilute to the mark with freshly boiled distilled water, close the flask with a solid stopper, mix thoroughly for 4 or 5 minutes and let settle for 30 minutes.

Pipette a 200-cc. portion, add phenolphthalein and titrate slowly with 0.5 N hydrochloric acid until the solution remains colorless on standing 1 minute. Call this additional number of cubic centimeters B. Then the percentage of available $CaO = 2A + 5B$.

NOTES.

To secure accurate and concordant results, it is essential that this method be followed in minute detail.

For very accurate work 0.1 N acid may be used in place of the 0.5 N acid prescribed. The calculation then becomes: Available $CaO = 2A + B$.

Standard acid solutions must be standardized by the U. S. Bureau of Standards benzoic acid No. 48-A through a sodium hydroxide solution.

PREPARATION OF STANDARD SOLUTION OF POTASSIUM PERMANGANATE.

Potassium Permanganate.

Prepare a solution of potassium permanganate containing 5.64 g. of the pure crystallized salt in each liter. Such a solution will be of such strength that 1 cc. will approximately equal 0.005 g. of CaO (Note 25).

The best and simplest way to prepare such a solution is to weigh out the required quantity of potassium permanganate and place in a bottle containing the proper volume of water a week or ten days before the solution is to be standardized. The bottle and its contents must be kept in a dark place and shaken occasionally for the first three or four days. When ready for standardization, siphon off the solution through a glass siphon into another bottle, leaving a depth of about one inch of solution undisturbed in the original bottle (Note 26). Thoroughly mix the solution in the second bottle by shaking and standardize as follows (Note 27):

Dissolve 0.5 g. of $Na_2C_2O_4$ (Note 28) in a 400-cc. beaker with 200 to 250 cc. of hot water (80 to 90° C.) and add 10 cc. of dilute H_2SO_4 (1 : 1) to the solution. Titrate at once with the permanganate solution being standardized, stirring vigorously and continuously. The permanganate solution must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate solution necessary to give the end point color is determined by running a blank determination in another beaker containing the same volume of acid and water present in the original beaker, and heated to the same temperature (Note 29). The value of the permanganate solution in grams of CaO per cubic centimeter of solution may be calculated from the following equations:

$$5Na_2C_2O_4 + 2KMnO_4 + 8H_2SO_4 = 5Na_2SO_4 + K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O.$$

$$5CaC_2O_4 + 2KMnO_4 + 8H_2SO_4 = 5CaSO_4 + K_2SO_4 + 2MnSO_4 + 10CO_2 + 8H_2O.$$

NOTES.

1. Ignitions in electric muffles are far superior to flame ignitions. If an electric muffle is not available, flame ignition and the blast lamp may be used.

2. If a platinum dish is not available, porcelain may be used. A glass container positively must *not* be used.

3. Instead of strong acid, that of half strength may be used and the heating begun at once.

4. For ordinary control work in the plant laboratory this correction may, perhaps, be neglected; the double evaporation must never be neglected.

5. Fusion with pyrosulfate is to be avoided on account of the subsequent introduction of sulfates into the solution.

6. This precipitate may also contain TiO_2, P_2O_5, and Mn_3O_4.

7. Where the iron is present in small quantities it is rather unsatisfactory to determine it in the ignited oxides from the 0.5-g. sample. Under these conditions the alternative method may be used.

8. The pyrosulfates are less troublesome and more effective than the bisulfates.

9. This correction for impurities should not be made when the hydrofluoric acid correction of the main silica determination has been omitted. After two evaporations, 1 to 2 mg. of silica are still to be found with the R_2O_3 precipitate.

10. Zinc will also reduce titanium. If this metal is to be determined and deducted from Al_2O_3, then H_2S must be used for reduction (boiling out the H_2S in a stream of CO_2 before titration). If titanium is not to be determined, the slight error introduced by its reduction with zinc is so small as to be negligible except in the most exact and detailed analyses.

11. The gravimetric method must be employed when a recovery of aluminum is desired, or when a determination of strontium is contemplated.

12. Care must be exercised in this washing, as 1000 cc. of boiling water will dissolve over 1 cg. of CaC_2O_4.

13. The volumetric method may be used for ordinary control work in the plant laboratory. It must be borne in mind that in this method all strontium oxide is reported as calcium oxide.

14. Use not more than 125 cc. for this washing.

15. The less the amount of magnesium present, the longer the precipitate must be allowed to settle.

16. Made by diluting NH_4OH with distilled water until the solution contains 2½ per cent NH_3 by weight. Three or four drops of HNO_3 (sp. gr. 1.42) are then added.

17. When manganese is present in the limestone, it will be caught in large part with the magnesium precipitate. (See U. S. Geological Survey *Bulletin 700*, p. 134.) In case manganese was not eliminated before this precipitation, the weighed pyrophosphate must be dissolved in HNO_3, tested for manganese with bismuthate, the manganese determined and deducted as $Mn_2P_2O_7$.

18. This determination may be made if desired upon the 0.5-g. sample ignited for solution in HCl. See first page of these methods under " Treatment of Sample."

19. With burned lime and hydrated lime this determination may be omitted. Even when made in an atmosphere free from CO_2 the dried sample absorbs CO_2 sufficiently rapidly during weighing to make the result of questionable value.

20. Boiling for one minute is usually sufficient.

21. In limestones very low in phosphorus it may be deemed desirable to concentrate the phosphorus from a considerable weight of sample. In this case, proceed as directed by F. Hinden (*Zeitschr. Anal. Chemie*, Vol. 54, p. 214 (1915)), as follows: To the nitric acid solution of the large sample add a few drops of Fe_2Cl_6 solution and then NH_4OH until the liquid becomes slightly turbid. Then add 0.5 g. of pure precipitated $CaCO_3$ and boil for five minutes. Filter, dissolve the precipitate in dilute HNO_3 and proceed as above.

22. Titanium and vanadium, which interfere in this determination, should not be encountered in appreciable amounts in this class of material.

Instead of the specified alkalimetric titration method, the phosphorus in the phosphomolybdate may be determined as magnesium pyrophosphate (U. S. Geological Survey *Bulletin 700*, pp. 178–179), or by the reductor method (A. A. Blair, " Chemical Analysis of Iron," 8th Edition, pp. 91–92).

23. The persulfate method may be employed if desired.

24. The separation of manganese with the R_2O_3 precipitate by the use of bromine is not recommended on account of the incompleteness of the precipitation. Separation of manganese by means of ammonium sulfide after the ammonia precipitation is also undesirable on account of the introduction of the reagent and the slimy character of the precipitate.

See also Note 17 concerning the contamination of magnesium pyrophosphate by manganese pyrophosphate and the need of corrective measures when manganese is present in the material under analysis.

25. With high calcium limes, more than 50 cc. of this solution will probably be required to titrate the liberated oxalic acid. In such cases the use of a larger burette is to be preferred to increasing the strength of the permanganate solution.

26. The siphon should not extend nearer than 1 in. from the bottom of the original bottle.

27. This solution should be standardized at least once every week. It will be found more convenient to make a solution as above described and standardize it every week, than to attempt, by boiling and filtering, to make a solution which will not change.

28. Sodium oxalate for standardization of potassium permanganate solution should be purchased from the U. S. Bureau of Standards, Washington, D. C. This material is sold by the Bureau of Standards as Sample No. 40a.

29. When the end point is reached, the temperature of the solution should not be below 60° C.

APPENDIX

ANALYSIS OF LIMESTONE OR LIME PRODUCTS

(Name of company)

Date
Lab. No.
Name
Date Rec'd
Material
Sample Marked

CONSTITUENTS DETERMINED

Name	Formula	Per cent
Silica	SiO_2	
Iron oxide	Fe_2O_3	
Aluminum oxide	Al_2O_3	
Calcium oxide	CaO	
Magnesium oxide	MgO	
Total sulfur	S	
Sulfur trioxide	SO_3	
Phosphorus pentoxide	P_2O_5	
Carbon dioxide	CO_2	
Water at 120° C	H_2O	
Water total	H_2O	
Insoluble		
Loss on ignition		
Available lime		
Total neutralizing value in terms of $CaCO_3$ Calculated		
Total neutralizing value in terms of $CaCO_3$ Determined		
Plasticity		
Soundness		

CONSTITUENTS CALCULATED[a]

Name	Formula	Per cent
Calcium carbonate	$CaCO_3$	
Calcium hydroxide	$Ca(OH)_2$	
Magnesium carbonate	$MgCO_3$	
Magnesium hydroxide	$Mg(OH)_2$	
Calcium sulfate	$CaSO_4$	

[a] Method for calculation *must* be noted for each constituent.

SIEVE ANALYSIS

Sieve No.						
Opening in microns						
Per cent passing						

REMARKS

NOTE.—Unless otherwise noted all determinations have been made according to methods prescribed by the American Society for Testing Materials.

Signed

TENTATIVE METHOD OF TEST
FOR
RESISTANCE OF FIRE-CLAY BRICK TO SPALLING ACTION[1]

Serial Designation: C 38 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1926.

Object. 1. The object of this test is to determine the resistance of high-duty fire-clay brick to spalling action, by subjecting them to repeated rapid temperature changes.

Preparation of Samples. 2. (*a*) The sample shall consist of at least five standard 9-in. brick or of five shapes, which may be cut to standard size with a grinding wheel.

(*b*) Test specimens of shapes such as boiler arch brick shall be cut to the standard 9-in. size. For this purpose a "cut-off" wheel is recommended.

Procedure. 3. (*a*) The specimens shall be weighed and placed in a door of a furnace operated at 1350° C. (2462° F.), care being taken to prevent the direct heating of more than the $2\frac{1}{2}$ by $4\frac{1}{2}$-in. end. After one hour the specimen shall be withdrawn from the furnace and stood on end in a tank of flowing cold water from 10 to 21° C. (50 to 70° F.) so that the hot end of the brick will be immersed to a depth of 2 in. After three minutes the sample shall be withdrawn from the water, allowed to steam five minutes and then returned to the furnace. The door of the furnace shall be closed while the bricks are out to prevent the lowering of the temperature. The alternate heating and cooling shall be continued in hourly cycles until the end of the brick spalls off.

(*b*) When pieces begin to fall off, the sample is laid on a 4.5 by 9.0-in. asbestos board, divided into one hundred equal squares, and the approximate percentage of loss estimated after each removal from the water. After the completion of the test, the brick is again weighed and the percentage of loss determined.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

(*c*) As an alternate for water dipping, air cooling may be used. This method should be used where the spalling is too rapid to get comparative results by the water dipping method. In this case the hot end of the brick shall be placed facing the air blast, 4 in. from the end of a 2-in. pipe from a $\frac{1}{4}$-h.p. blower, delivering between 28 and 30 cu. ft. of air per minute.

Reporting Results.

4. The report shall show the number of dips before loss started, the percentage of loss after each cooling, the total number of dips and the final percentage of loss by weight.

TENTATIVE DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY[1]

Serial Designation: C 11 - 26 T

This is a Tentative Standard only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1916; REVISED, 1921, 1922, 1923, 1924, 1925, 1926.

Aggregate.—Any inert material used as a filler in stucco, plaster, mortar, concrete, etc., without regard to its function as a binding material.

Consistency.—The degree of wetness of a plastic mixture.

Gypsum Plaster Board.—A sheet composed of an incombustible core of gypsum, surfaced with paper or other fibrous material which is firmly bonded to the core, or with intermediate layers of such material within the core, or an incombustible sheet of gypsum with not more than 15 per cent by weight of fiber intimately mixed; and designed to be used as a lath for the reception of gypsum plaster.

Gypsum Wall Board.—A sheet composed of an incombustible core of gypsum, surfaced with paper or other fibrous material which is firmly bonded to the core, and designed to be used, without the addition of plaster, for walls, ceilings or partitions and affording a surface suitable to receive decoration.

Plasticity.—The yielding property of a wet mixture to change of form.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, 844 Rush St., Chicago, Ill.

These Definitions, when adopted as standard, will be added to the present Standard Definitions of Terms Relating to the Gypsum Industry (Serial Designation: C 11 - 26), A.S.T.M. Standards Adopted in 1926.

TENTATIVE DEFINITIONS OF THE TERMS SAND AND AGGREGATE[1]

Serial Designation: C 58 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1926.

Aggregate.—Designated inert material, which when bound together into an agglomerated mass by a matrix forms concrete, mastic, mortar, plaster, etc.

Sand.—The fine granular material (usually less than $\frac{1}{4}$ in. in diameter) resulting from the natural disintegration of rock, or from the crushing of friable sandstone rocks.

NOTE.—When used without a qualifying adjective, "sand" is generally understood to mean the product of the natural disintegration of siliceous or calcareous rock. Sand should be distinguished from screenings, gravel, etc. The size of particle and other physical characteristics should be taken care of in specifications. The fine material resulting from the crushing of blast-furnace slag is known as "slag sand."

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. L. R Ferguson, Chairman of the Sub-Committee, of Committee E-8, on Definition of Sand and Aggregate Louisiana Portland Cement Co., 1120 Hibernia Bank Building, New Orleans, La.

TENTATIVE SPECIFICATIONS
FOR
RAW LINSEED OIL[1]

Serial Designation: D 234 – 26 T

This is a Tentative Standard only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

I. PROPERTIES AND TESTS

Properties.

1. Linseed oil shall be the pure oil pressed from flaxseed and shall conform to the following requirements:

	MAXIMUM	MINIMUM
Specific Gravity 15.5°/15.5° C	0.935	0.931
Acid Number	4.0	.....
Saponification Number	195.0	189.0
Unsaponifiable Matter, per cent	1.50	.....
Iodine Number (Wijs)[a]	.....	180.0
Loss on Heating at 105–110° C., per cent	0.2	.....
Color	Not darker than a freshly prepared solution of 1.0 g. potassium bichromate in 100 cc. pure concentrated sulfuric acid (sp. gr. 1.84).	
Foots, per cent:		
Heated Oil	1.0	.....
Chilled Oil	4.0	.....

[a] If linseed oil of the high-iodine-number type is desired, the minimum iodine number, as specified above, should be changed to 188.0.

II. METHODS OF TESTING

Methods of Testing.

2. The oil should be tested in accordance with the following methods:

General.—All tests shall be made on oil which has been thoroughly agitated before the removal of a portion for analysis.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Purity of Raw Linseed Oil from North American Seed (D 1 – 15), 1924 Book of A.S.T.M. Standards. The specifications also supersede the Tentative Specifications for Purity of Raw Linseed Oil from South American Seed (D 77 – 21 T) and the Tentative Specifications for Foots Permissible in Properly Clarified Pure Raw Linseed Oil from North American Seed (D 51 – 18 T).

Specific Gravity.—Use a pyknometer, accurately standardized and having a capacity of at least 25 cc., or any other equally accurate method, making the test at 15.5° C. water being 1.000 at 15.5° C.

Acid Number.—Weigh from 5 to 10 g. of the oil. Transfer to a 300-cc. Erlenmeyer flask. Add 50 cc. of a mixture of equal parts by volume of 95-per-cent ethyl alcohol and c.p. reagent benzol. (This mixture should be previously titrated to a very faint pink with dilute alkali solution, using phenolphthalein as an indicator.) Add phenolphthalein indicator and titrate at once to a faint permanent pink color with 0.2 N sodium hydroxide solution. Calculate the acid number (milligrams KOH per gram of oil).

Saponification Number.—Weigh about 2 g. of the oil in a 300-cc. Erlenmeyer flask. Add 25 cc. of alcoholic sodium hydroxide or potassium hydroxide solution. Put a condenser loop inside the neck of the flask and heat on the steam bath for one hour. Cool, add phenolphthalein as indicator, and titrate with 0.5 N H_2SO_4. Run two blanks with the alcoholic sodium hydroxide solution. These should check within 0.1 cc. 0.5 N H_2SO_4. From the difference between the number of cubic centimeters of 0.5 N H_2SO_4 required for the blank and for the determination, calculate the saponification number (milligrams KOH required for 1 g. of the oil).

Unsaponifiable Matter.—Weigh 8 to 10 g. of the oil. Transfer to a 250-cc. long-neck flask. Add 5 cc. of a strong solution of sodium hydroxide (equal weights of NaOH and H_2O) and 50 cc. of 95-per-cent ethyl alcohol. Put a condenser loop inside the neck of the flask and boil for two hours. Occasionally agitate the flask to break up the liquid, but do not project the liquid onto the sides of the flask. At the end of two hours, remove the condenser and allow the liquid to boil down to about 25 cc.

Transfer to a 500-cc. glass-stoppered separatory funnel, rinsing with water. Dilute with water to 250 cc., add 100 cc. of redistilled ether. Stopper and shake for one minute. Let stand until the two layers separate sharp and clear. Draw all but one or two drops of the aqueous layer into a second 500-cc. separatory funnel and repeat the process using 60 cc. of ether. After thorough separation, draw off the aqueous solution into a 400-cc. beaker, then the ether solution into the first separatory funnel, rinsing down with a little water. Return the aqueous solution to the second separatory funnel and shake out again with 60 cc. of ether in a similar manner, finally drawing the aqueous solution into the beaker and rinsing the ether into the first separatory funnel.

Shake the combined ether solution with the combined water rinsings and let the layers separate sharp and clear. Draw off the water and add it to the main aqueous solution. Shake the ether solution with two portions of water (about 25 cc. each). Add these to the main water solution.

Swirl the separatory funnel so as to bring the last drops of water down to the stopcock and draw off until the ether solution just fills the bore of the stopcock. Wipe out the stem of the separatory funnel with a bit of cotton on a wire. Draw the ether solution (portionwise if necessary) into a 250-cc. flask and distill off. While still hot drain the flask into a small weighed beaker, rinsing with a little ether. Evaporate this ether, cool the beaker and weigh. (The unsaponifiable oil from adulterated drying oils may be volatile and as a consequence may evaporate on long heating. Therefore, heat the beaker on a warm plate, occasionally blowing out with a current of dry air. Discontinue heating as soon as the odor of ether is gone.)

Iodine Number.—Place a small quantity of the sample in a small weighing burette or beaker. Weigh accurately. Transfer by dropping from 0.09 to 0.15 g. of oil to a 500-cc. bottle, having a well-ground glass stopper, or an Erlenmeyer flask, having a specially flanged neck for the iodine tests. Reweigh the burette or beaker and determine the amount of sample used. Add 10 cc. of chloroform. Whirl the bottle to dissolve the sample. Add 10 cc. of chloroform to each of two empty bottles like that used for the sample. Add to each bottle 25 cc. of the Wijs solution and let stand with occasional shaking for 1 hour in a dark place at a temperature of from 21 to 23° C. Add 10 cc. of the 15-per-cent potassium iodide solution and 100 cc. of water. Titrate with 0.1 *N* sodium thiosulfate, using starch as an indicator. The titrations on the two blank tests should agree within 0.1 cc. From the difference between the average of the blank titrations and the titration on the samples and the iodine value of the thiosulfate solution calculate the iodine number of the samples tested. (Iodine number is given in centigrams of iodine to 1 g. of sample.)

Preparation of Wijs Iodine Monochloride Solution.—Dissolve iodine in glacial acetic acid that has a melting point of 14.7 to 15° C. and is free from reducing impurities in the proportion so that 13 g. of iodine will be present in 1000 cc. of solution. The preparation of the iodine monochloride solution presents no great difficulty, but it shall be done with care and accuracy in order to obtain satisfactory results. There shall be in the solution no sensible excess either of iodine or more particularly of chlorine over that required to form the monochloride. This condition is most satisfactorily attained by dissolving in the whole of the acetic acid to be used the requisite quantity of iodine, using a gentle heat to assist the solution, if it is found necessary. Set aside a small portion of this solution while pure, and pass dry chlorine into the remainder until the halogen content of the solution is doubled. Ordinarily it will be found that by passing the chlorine into the main part of the solution until the characteristic color of free iodine has just been discharged, there will be a slight excess of chlorine, which is corrected by the addition of the requisite amount of the unchlorinated portion until all free chlorine has been destroyed. A slight excess of iodine does little or no harm, but excess of chlorine must be avoided.

Loss on Heating at 105 to 110° C.—Place 10 g. of the oil in an accurately weighed 50-cc. Erlenmeyer flask and weigh. Heat in an oven at a temperature between 105 and 110° C. for 30 minutes, then cool and weigh. Calculate the percentage loss. This determination shall be made in a current of carbon dioxide gas.

Color.—Prepare a fresh solution of 1 g. pure potassium bichromate in 100 cc. of pure concentrated colorless sulfuric acid (sp. gr. 1.84). Place the oil and colored concentrated solution in separate thin-walled clear-glass tubes of the same diameter (1 to 2 cm.) to a depth of not less than 25 cm., and compare the depths of color by looking transversely through the columns of liquid by transmitted light.

Determination of Percentage Foots.—Method.—With all materials at a temperature between 20 and 27° C., mix, by shaking for exactly one minute in a graduated tube, 25 cc. of the well-shaken sample of oil, 25 cc. of acetone and 10 cc. of the acid calcium chloride solution. The tube shall then be clamped in an upright position where settling can take place for 24 hours. The temperature during this period should be between 20 and 27° C.

The volume of the stratum lying between the clear calcium chloride solution and the clear acetone and oil mixture is read in 0.1 cc. or a fraction thereof. This reading multiplied by four expresses the amount of foots present as a percentage by volume.

The tube referred to may be a burette or a color comparison tube. It should have an internal diameter of 1.0 to 1.5 cm., and a capacity of not less than 70 cc. The graduations in 0.1 cc. should extend at least from 10 cc. to 50 cc. above the bottom of the tube. The acid calcium chloride solution is prepared by saturating with calcium chloride a mixture of 90 parts water and 10 parts concentrated hydrochloric acid (sp. gr. 1.19).

Heated Oil Test.—Heat a portion of the oil to 65° C., hold it within 2° C. of that temperature for 10 minutes; then cool it to room temperature (20 to 27° C.). Subject the sample promptly to the foots test as described above.

Chilled Oil Test.—Heat a portion to 65° C., hold it within 2° C. of that temperature for 10 minutes; then place it in a dry clean bottle, stopper tightly, and place in a cracked ice and water mixture (0° C.) for exactly 2 hours. At the end of this time, place the bottle for exactly 30 minutes in a water bath at 25° C., then subject promptly to the foots test.

TENTATIVE SPECIFICATIONS
FOR
PETROLEUM SPIRITS (MINERAL SPIRITS)[1]

Serial Designation: D 235 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope.

1. These specifications apply only to petroleum distillates.

I. PROPERTIES

Properties.

2. The material shall conform to the following requirements:

(*a*) *Appearance.*—It shall be clear and free from suspended matter and water.

(*b*) *Color.*—The color shall be "water white," that is, not darker than No. 21 Saybolt Chromometer.

(*c*) *Flash Point.*—The flash point shall not be lower than 86° F. (30° C.) when tested in the Tag closed tester.

(*d*) *Blackening.*—It shall not blacken or corrode clean metallic copper in 30 min. at the boiling point of the spirits.

(*e*) *Distillation.*—The distillate below 266° F. (130° C.) shall not exceed 5 per cent.

The distillate below 446° F. (230° C.) shall not be less than 97 per cent.

(*f*) *Acidity.*—The residue after distillation shall be neutral.

II. METHODS OF TEST

Methods of Testing.

3. The properties enumerated in these specifications shall be determined in accordance with the following methods of test:

(*a*) *Color.*—The test for color shall be in accordance with the Tentative Method of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer (Serial Designation: D 156 - 23 T) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 682 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 432.

A fresh aqueous solution of potassium dichromate in distilled water, containing 0.0048 g. K_2 CR_2 0_7 per liter, is approximately equivalent to No. 21 Saybolt Chromometer.

(*b*) *Flash Point.*—The test shall be made in accordance with the Standard Method of Test for Flash Point of Volatile Flammable Liquids (Serial Designation: D 56) of the American Society for Testing Materials.[1]

Blackening.—A clean strip of mechanically polished pure sheet copper, about ½ in. (1.3 cm.) in width and 3 in. (7.5 cm.) in length, shall be placed in a glass test tube about ¾ in. (1.9 cm.) in width and 18 in. (46 cm.) in length. Sufficient of the sample to be tested shall be added to completely cover the strip and heated rapidly to boiling. It is most convenient to heat the tube by immersion in an oil bath maintained at a temperature slightly higher than the initial boiling point of the mineral spirits. The sample shall be kept boiling for 30 minutes without any actual distillation taking place and the copper strip then examined for blackening. A slight tarnish shall be disregarded, but any marked blackening shall be cause for rejection.

Distillation.—The test shall be in accordance with the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (Serial Designation D 86 - 26 T) of the American Society for Testing Materials.[2]

Acidity.—The cooled residue from the distillation flask shall be collected in a test tube, three volumes of distilled water added, and the tube thoroughly shaken. The mixture shall be allowed to separate and the aqueous layer removed to a clean test tube by means of a pipette. One drop of a 1-per-cent solution of methyl orange shall be added. No pink or red color should be formed.

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[1] 1924 Book of A.S.T.M. Standards.

[2] See p. 816.

TENTATIVE SPECIFICATIONS
FOR
DESTRUCTIVELY DISTILLED WOOD TURPENTINE[1]

Serial Designation: D 236 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

1. These specifications apply only to destructively-distilled wood turpentine obtained in the destructive distillation of resinous wood.

I. PROPERTIES AND TESTS

2. The destructively distilled wood turpentine shall be pure and conform to the following requirements:

Appearance. 3. It shall be clear and free from suspended matter and water.

Color. 4. The color shall be "Standard" or better.

Odor. 5. The odor shall be characteristic of destructively-distilled wood turpentine and, if desired, shall conform to the odor of the sample agreed upon.

Other Properties. 6. Other properties shall be as follows:

	MAXIMUM	MINIMUM
Specific gravity, 15.5°/15.5° C.	0.875	0.860
Refractive index at 20° C.	1.483	1.463
Residue after polymerization with 38 N H_2SO_4:		
Volume, per cent	2.0	.....
Refractive index at 20° C.	...	1.480
Initial boiling point at 760 mm. pressure	157° C.	150° C.
Distillation below 170° C. at 760 mm. pressure, per cent	...	60
Distilling below 180° C. at 760 mm. pressure, per cent	...	90

II. METHODS OF TEST

Methods of Testing. 7. The sampling and methods of testing shall be conducted in accordance with the Standard Methods of Sampling and Testing Turpentine (Serial Designation: D 233) of the American Society for Testing Materials.[2]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

[2] A.S.T.M. Standards Adopted in 1926.

TENTATIVE SPECIFICATIONS
FOR
ORANGE SHELLAC[1]

Serial Designation: D 237 – 26 T

This is a Tentative Standard only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Grades. 1. Orange shellacs may, for convenience, be grouped into the four following grades: Grade A, Grade B, Grade C and Grade D. Stick, seed, garnet and button lacs are not included under these grades.

I. PROPERTIES

Properties. 2. Orange shellac shall conform to the following requirements:

	GRADE A	GRADE B	GRADE C	GRADE D
Iodine number, maximum	18.0	18.0	18.0	24.3
Matter insoluble in hot 95-per-cent alcohol, maximum per cent	1.75	2.50	3.00	3.00
Moisture and volatile matter, maximum, per cent	2.0	2.0	2.0	2.0
Matter soluble in water, maximum, per cent	0.5	0.5	0.5	0.5
Wax, maximum, per cent	5.5	5.5	5.5	5.5
Ash, maximum, per cent	1.0	1.0	1.0	1.0

II. SAMPLING

Sampling. 3. (*a*) Only original packages shall be sampled.

(*b*) Samples shall be drawn by hand, or a suitable tryer may be used, preferably from not less than 10 per cent of the lot.

(*c*) In sampling "free" shellac, approximately double handfuls shall be drawn from each bag and quartered down to approximately 2 lb. The shellac shall then be ground to pass through a No. 20 sieve (840 micron opening), half of which shall be reserved by the buyer, the other half used for analysis.

(*d*) In sampling "blocky" or "matted" (hard) shellac, about 1 lb. from each bag sampled shall be ground to pass a $\frac{1}{4}$-in. sieve. This shall then be quartered down to approximately a 2-lb. sample which shall be ground to pass through a No. 20 sieve (840 micron opening) and divided as in sampling "free" shellac.[1]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

III. METHODS OF TESTING

4. The determination of iodine number, matter insoluble in hot alcohol, moisture and wax shall be made in accordance with the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials,[2] and the Standard Method of Test for Determination of Wax in Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[3]

5. The determination of matter soluble in water shall be made as follows:

Weigh 10 to 25 g. of the sample accurately and stir thoroughly with 100 cc. of distilled water in a suitably sized flask or beaker. Cover with a watch glass and allow to stand at room temperature (approximately 21° C.) for four hours, stirring occasionally. Decant the water through a 12.5-cm. filter paper into a weighed evaporating dish, washing the shellac and paper with at least 50 cc. more of water. Evaporate the water and dry the extract at 105 to 110° C. for one hour or more to constant weight. Cool, weigh, and calculate the percentage of matter soluble in water.

6. The determination of ash shall be made as follows:

Approximately 2 to 3 g. of the sample shall be accurately weighed, transferred to a weighed porcelain or platinum crucible and ignited at as low a temperature as possible until all organic matter has been destroyed. The crucible and contents shall be cooled and weighed and the percentage of ash calculated.

EXPLANATORY NOTES

In general, Grade A will include grades of shellac known in the trade as D.C., VSO, Diamond I, Double Triangle G and Superfine.

In general, Grade B will include the grades known in the trade as Fine, Good and Heart Brands.

Grade C represents the grade known in the trade as Pure TN.

Grade D represents the grade known in the trade as U.S.S.A. TN, and which may contain up to 3 per cent of rosin.

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[1] The above is a brief abstract of the Rules and Regulations of the United States Shellac Importers Association.

[2] 1924 Book of A.S.T.M. Standards.

[3] A.S.T.M. Standards Adopted in 1925.

TENTATIVE SPECIFICATIONS
FOR
CHROME YELLOW[1]

Serial Designation: D 211 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope.

1. These specifications cover the pigments commonly known as lemon chrome yellow, medium chrome yellow, and orange chrome yellow. The pigment may be purchased in the dry form or ground in oil, or in japan, to form a paste.

I. MANUFACTURE

Process.

2. (*a*) *Dry Pigments.*—The dry pigments shall be chemical precipitates consisting of normal or basic lead chromates or mixtures of these with or without admixtures of other insoluble compounds of lead, but without any other admixtures.

(*b*) *Pastes in Oil.*—The pastes in oil shall be made by thoroughly grinding the specified pigments with pure raw or refined linseed oil.

(*c*) *Pastes in Japan.*—The pastes in japan shall be made by thoroughly grinding the specified pigments in high-grade grinding japan.

II. PROPERTIES AND TESTS

Composition and Properties.

3. (*a*) The color and tone shall be equal to, and the tinting strength not less than, that of a sample mutually agreed on by buyer and seller.

(*b*) The dry pigments shall meet the following requirements:

Total matter soluble in water, maximum, per cent	0.5
Total of all substances other than insoluble compounds of lead, maximum, per cent	3.0
Organic colors or lakes	None
Coarse particles (total residue on a No. 325 screen), per cent, not over	1.0

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

(*c*) *Paste in Oil.*—The pastes as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. They shall mix readily in all proportions without curdling, with linseed oil, turpentine, or volatile mineral spirits, or any combination of these substances.

The pastes shall meet the following requirements:

Pigment, minimum, per cent	75
Linseed oil, maximum, per cent	25
Water and other volatile matter, maximum, per cent	0.7
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	1.5

(*d*) *Paste in Japan.*—The pastes as received shall not be caked in the container and shall break up readily in turpentine to form a smooth paint of brushing consistency that will dry within one hour to a hard flat coat. They shall meet the following requirements:

Pigment, minimum, per cent	70
Vehicle (japan), maximum, per cent	30
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	1.5
Non-volatile matter in the vehicle, minimum, per cent of the vehicle	40

Number of Tests.

4. One sample shall be taken at random from each lot of 1000 packages or less. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

NOTE.—For determining coarse particles, screens 3 in. in diameter are recommended. The screen cloth is described as follows: No. 325 cloth of the U. S. Standard Sieve Series should be made of wire 0.036 mm. (0.0014 in.) in diameter, a tolerance of 15 per cent under and 35 per cent over being allowed on this diameter. The average opening between adjacent parallel wires should be 0.044 mm. (0.0017 in.), the tolerance being 8 per cent with the additional limitation that the maximum opening shall not exceed 0.044 mm. by more than 90 per cent.

TENTATIVE SPECIFICATIONS
FOR
PURE CHROME GREEN[1]

Serial Designation: D 212 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope.

1. These specifications cover what is commercially known as pure chrome green. The pigment may be purchased in the dry form or ground in oil or in japan to form a paste.

I. MANUFACTURE

Process.

2. (*a*) *Dry Pigment.*—The pigment shall be a precipitated mixture of lead chromate and iron ferro and ferricyanide blue, with or without other insoluble compounds of lead.

(*b*) *Paste in Oil.*—The paste in oil shall be made by thoroughly grinding the specified pigment with pure raw or refined linseed oil.

(*c*) *Paste in Japan.*—The paste in japan shall be made by thoroughly grinding the specified pigment with high-grade grinding japan.

II. PROPERTIES AND TESTS

Composition and Properties.

3. (*a*) The color and tone shall be equal to, and the tinting strength not less than, that of a sample mutually agreed on by buyer and seller.

(*b*) *Dry Pigment.*—The dry pigment shall meet the following requirements:

Percentage of total lead present in the form of chromate, minimum	70
Total impurities, maximum, per cent	3
Coarse particles (total residue retained on a No. 325 screen), maximum, per cent	1.0

(*c*) *Paste in Oil.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions, without curdling, with linseed oil, turpentine, or volatile mineral spirits, or any combination of these substances. The paste shall meet the following requirements:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Pigment, minimum, per cent	70
Linseed oil, maximum, per cent	30
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	1.5

(*d*) *Paste in Japan.*—The paste as received shall not be caked in the container and shall break up readily in turpentine to form a smooth paint of brushing consistency that will dry within one hour to a hard, flat coat. The paste shall meet the following requirements:

Pigment, minimum, per cent	65
Vehicle (japan), maximum, per cent	35
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	1.5
Non-volatile matter in vehicle, minimum, per cent of the vehicle	40

Number of Tests.

4. One sample shall be taken at random from each lot of 1000 packages or less. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

NOTE.—For determining coarse particles, screens 3 in. in diameter are recommended. The screen cloth is described as follows: No. 325 cloth of the U. S. Standard Sieve Series should be made of wire 0.036 mm. (0.0014 in.) in diameter, a tolerance of 15 per cent under and 35 per cent over being allowed on this diameter. The average opening between adjacent parallel wires should be 0.044 mm. (0.0017 in.), the tolerance being 8 per cent with the additional limitation that the maximum opening shall not exceed 0.044 mm. by more than 90 per cent.

TENTATIVE SPECIFICATIONS
FOR
REDUCED CHROME GREEN[1]

Serial Designation: D 213 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope. 1. These specifications cover what is known commercially as reduced chrome green, also known as grinders green. The pigment may be purchased in the dry form or ground in oil or in japan to form a paste.

I. MANUFACTURE

Process. 2. (*a*) *Dry Pigment.*—The pigment shall be a mixture of lead chromate and iron ferro and ferricyanide blue, with or without other insoluble compounds of lead, precipitated on a base of barium sulfate or insoluble siliceous material or any mixture thereof.

(*b*) *Paste in Oil.*—The paste in oil shall be made by thoroughly grinding the specified pigment with pure raw or refined linseed oil.

(*c*) *Paste in Japan.*—The paste in japan shall be made by thoroughly grinding the specified pigment in high-grade grinding japan.

II. PROPERTIES AND TESTS

Composition and Properties. 3. (*a*) The color and tone shall be equal to, and the tinting strength not less than, that of a sample mutually agreed on by buyer and seller.

(*b*) The dry pigment shall meet the following requirements:

	MAXIMUM	MINIMUM
Sum of the barium sulfate and insoluble siliceous material, per cent	80	..
Color (total of insoluble lead compounds and iron blue), per cent	..	20
Percentage of total lead present in the form of chromate	..	70
Total calcium oxide in any form soluble in acid, per cent	1.0	..
Coarse particles (total residue retained on a No. 325 screen), per cent	1.5	..

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

(*c*) *Paste in Oil.*—The paste as received shall not be caked in the container and shall break up readily in oil to form a smooth paint of brushing consistency. It shall mix readily in all proportions without curdling, with linseed oil, turpentine, or volatile mineral spirits, or any combination of these substances. The paste shall meet the following requirements:

Pigment, minimum, per cent	80
Linseed oil, maximum, per cent	20
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent of the pigment	2.0

(*d*) *Paste in Japan.*—The paste as received shall not be caked in the container and shall break up readily in turpentine to form a smooth paint of brushing consistency that will dry within one hour to a hard flat coat. It shall meet the following requirements:

Pigment, minimum, per cent	75
Vehicle (japan), maximum, per cent	25
Coarse particles and skins (total residue retained on a No. 325 screen), maximum, per cent	2.0
Non-volatile matter in vehicle, minimum, per cent of the vehicle	40

Number of Tests.

4. One sample shall be taken at random from each lot of 1000 packages or less. If the packages are of such size that 1000 packages amount to more than a carload, one sample shall be taken at random from each carload.

NOTE.—For determining coarse particles, screens 3 in. in diameter are recommended. The screen cloth is described as follows: No. 325 cloth of the U. S. Standard Sieve Series should be made of wire 0.036 mm. (0.0014. in.) in diameter, a tolerance of 15 per cent under and 35 per cent over being allowed on this diameter. The average opening between adjacent parallel wires should be 0.044 mm. (0.0017 in.), the tolerance being 8 per cent with the additional limitation that the maximum opening shall not exceed 0.044 mm. by more than 90 per cent.

TENTATIVE METHODS
OF
TESTING SHELLAC VARNISH[1]

Serial Designation: D 214 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Shellac varnishes are made by dissolving shellac in alcohol and are designated in the trade in terms of pounds of shellac per gallon of alcohol, the 4, 4.5 and 5-lb. cut goods being most commonly used. Specially denatured alcohol (Formula No. 1) is largely used, and occasionally wood alcohol and butyl alcohol are used. Pure grain alcohol, or Formula No. 35 denatured, is used for confectioner's varnish or glaze.

I. GENERAL

1. (*a*) All tests, unless otherwise stated, shall be made at room temperature between 21 and 32° C. (70 and 90° F.).

(*b*) The sample of shellac varnish shall be thoroughly agitated in the container immediately before portions are removed for the various tests and the unused portion shall be kept in a tightly stoppered glass container, in a dark place.

II. DETERMINATION OF COLOR

2. The color of the well-shaken sample shall be compared with the color of the well-shaken sample of shellac varnish mutually agreed upon for color by the buyer and seller. The color comparison shall be made in clear glass tubes of the same diameter.

III. DETERMINATION OF NON-VOLATILE MATTER

Method (*a*). APPARATUS

3. The apparatus shall consist of the following:

(*a*) A weighing bottle for volatile liquids or a Grethan pipette.

(*b*) A tin-foil dish, approximately $1\frac{1}{4}$ in. in height and $2\frac{1}{2}$ in. in diameter.

(*c*) Prepared Sand, prepared as follows: Sieve sea-sand to remove any foreign material. Digest with hot HCl for about one hour.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

Wash with water to remove all the acid and soluble impurities. Ignite and put in a desiccator to cool. Preserve in a tightly stoppered bottle.

PROCEDURE

Procedure.

4. Put 10 g. of the prepared sand and a short glass rod in the tin-foil dish. Record the exact weight of the dish and contents. Transfer about 1 g. of the sample from the weighing bottle to the dish. Record the exact weight of the sample taken which will be the difference in weight of the weighing bottle before and after the removal of the sample. Thoroughly mix the varnish and sand with the glass rod and place the dish in an oven maintained at 105° C. for one hour. Remove the dish from the oven, allow it to cool and weigh. The increase in weight of the tin-foil dish containing the sand and glass rod is the weight of the non-volatile matter in the sample of varnish taken.

Method (*b*).

5. Follow the procedure given in the Standard Methods of Testing Oleo-Resinous Varnishes (Serial Designation: D 154) of the American Society for Testing Materials,[1] for non-volatile matter in oleo-resinous varnish, with the exception that the weight of sample taken shall not exceed 1.5 g. With varnishes made by "cutting" over 5 lb. of shellac per gallon of alcohol, add 10 g. of sea sand, prepared as described in Section 3 (*c*), to the container and mix with the sample by means of a short glass rod (previously weighed with the container and sand).

Calculation of Body.

6. (*a*) Since bone dry white shellac may lose up to 5 per cent of its weight when heated at 105° C., the weight of non-volatile matter found in the case of white shellac varnish should be divided by the factor 0.95.

(*b*) On account of the efforts of the orange varnish manufacturers to produce cleaner varnish for the trade by the use of centrifuge machines and improved filtration apparatus, the same allowance of 5 per cent, which is made in calculating white shellac varnish body, shall be used in determining clarified orange varnish body. This 5-per-cent allowance is based on the fact that 2 per cent of moisture has always been allowed in the calculation, and in addition the 3 per cent of insoluble matter customarily encountered in varnish grades of orange shellac is eliminated by the modern methods of varnish production.

The calculations of the body of white and orange shellac varnishes are made according to the methods shown in the following examples:

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[1] 1924 Book of A.S.T.M. Standards.

Example.—

White Shellac Varnish and Clarified Orange Shallac Varnish:

Weight of varnish taken	1.2973 g.
Weight of residue (after drying)	0.5235 g.

$$\text{Per cent of body} = \frac{0.5235}{0.95 \times 1.2973} \times 100 = 42.45 \text{ per cent}$$

This percentage corresponds to 5 lb. per gallon.

The above orange-varnish calculation refers to ready-cut varnish as obtained in the regular paint and varnish shops.

The better grades of orange shellac, which contain little insoluble matter, can and are cut in alcohol and simply strained through an 80-mesh screen. Such a varnish would contain practically all the finely divided inert matter and the calculation of the body of such a varnish would be made as follows:

Since dry orange shellac may lose up to 2 per cent of its weight when heated at 105° C., the weight of non-volatile matter found in the case of orange shellac varnish should be divided by the factor 0.98.

The calculation of the body is made according to the method shown in the following example:

Example.—

Unclarified Orange Shellac Varnish:

Weight of varnish taken	1.3200 g.
Weight of residue (after drying)	0.5491 g.

$$\text{Per cent of body} = \frac{0.5491}{0.98 \times 1.3200} \times 100 = 42.45 \text{ per cent.}$$

This percentage corresponds to 5 lb. per gallon.

(*c*) To convert the percentage of solids (residue) of the varnish into pounds per gallon, from the percentage of solids expressed in pounds of solids in 100 lb. of varnish, the pounds of solvent is found by difference. The weight of solvent divided by 6.7793 (the weight of one gallon of denatured alcohol (Formula No. 1) at 16° C. (60° F.), gives the number of gallons of alcohol present. From this the number of pounds of shellac per gallon of alcohol is determined.

Example.—

100 − 30.68 (solids found) = 69.32 lb. of alcohol

$$\frac{69.32}{6.7793} = 10.23 \text{ gallons of alcohol.}$$

$$\frac{30.68}{10.23} = 3 \text{ lb. per gallon.}$$

For convenience, tables are appended hereto giving pounds of shellac per gallon for varnishes for various specific gravities.

IV. DETERMINATION OF MATTER INSOLUBLE IN HOT ALCOHOL

7. (*a*) Matter insoluble in hot alcohol shall be determined by the continuous extraction method or by the Gooch filtration method as given in the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[1]

(*b*) In the case of the continuous-extraction method, weigh an amount of shellac varnish corresponding, as closely as practicable, to 5 g. of non-volatile matter, while with the Gooch filtration method take a weight of sample corresponding closely to 2 g. of non-volatile matter.

V. DETERMINATION OF WAX

8. In the determination of wax, dilute an amount of the varnish that will contain approximately 10 g. of dry shellac with 95-per-cent specially-denatured alcohol to about 200 cc. and proceed as in the Standard Method of Test for Determination of Wax in Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[2]

VI. DETERMINATION OF PURITY

A. Qualitative Tests

9. (*a*) *Copal.*—Filter some of the varnish through dry paper into a large test tube (6 by $\frac{3}{4}$ in.). To 10 cc. of the filtrate add 99-per-cent methyl alcohol to nearly fill the tube and thoroughly mix. The formation of a precipitate after standing is an indication of copal. Shellac free from copal should remain clear under the conditions given above.

(*b*) *Rosin.*—Add 20 cc. of absolute alcohol or glacial acetic acid (melting point 13 to 14° C.) to 5 cc. of the varnish and thoroughly mix. Add 100 cc. of petroleum ether and again thoroughly mix. Add approximately 2 liters of water and separate a portion of the ether layer (at least 50 cc.) and filter if cloudy. Evaporate the petroleum ether and test the residue by the Halphen-Hicks reagent as follows:

Solution A.—One part by volume of phenol dissolved in 2 parts of carbon tetrachloride.

Solution B.—One part by volume of bromine dissolved in 4 parts of carbon tetrachloride.

Add 1 to 2 cc. of solution A to the residue left after evaporation of the petroleum ether solution. Pour this solution into a cavity of an ordinary porcelain color reaction plate and fill an adjacent cavity with solution B. Cover the plate with a watch glass and note the color, if any, produced by the action of bromine vapors on solution A. A decided purple or blue color is an indication of rosin.

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[1] 1924 Book of A.S.T.M. Standards.

[2] A.S.T.M. Standards Adopted in 1925.

B. Determination of Iodine Number

Method (*a*).

Procedure.

10. (*a*) With the percentage of solids known, weigh accurately in a suitable pipette, or weighing bottle for volatile liquids, an amount of varnish corresponding to 0.20 g. of dry shellac and transfer to a 250-cc. glass-stoppered bottle. In case heavy adulteration is suspected, weigh an amount of varnish corresponding to 0.15 g. of shellac or less if necessary.

(*b*) Warm the bottle in a water bath at a temperature of 75 to 80° C. for about 15 minutes, aspirating the alcohol vapor until the residue is practically dry. Cool and add 20 cc. of acetic acid (melting point, 14.8° C.). Proceed in accordance with the method for iodine number described in the determination of rosin in the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[1]

Method (*b*).

Alternate Procedure.

11. Transfer about 1.5 cc. of the varnish by means of a pipette to a flat-bottomed glass or porcelain dish at least 8 cm. in diameter. Add 1 to 2 cc. of 95-per-cent alcohol to spread the varnish evenly over the bottom of the dish. Heat the dish and contents at 75 to 80° C. for one-half hour. Scrape the residue from the dish, accurately weigh 0.20 g., and transfer to a 250-cc. glass-stoppered bottle. In case of badly adulterated samples, a proportionately smaller weight of sample should be taken. Proceed in accordance with the method for iodine number described in the determination of rosin in the Standard Methods of Testing Shellac (Serial Designation: D 29) of the American Society for Testing Materials.[1]

12. (*a*) If a qualitative test shows the presence of copal but no rosin, the amount may be estimated from iodine number, taking the iodine number of copal as 130 and making the calculation in an analogous manner to that for rosin described in Section 7 of the Standard Methods D 29.

(*b*) If a qualitative test shows the presence of rosin but no copal, the calculation of the percentage of rosin may be made as described in Section 7 of the Standard Methods D 29.

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[1] 1924 Book of A.S.T.M. Standards.

APPENDIX

Information concerning the volatile portion of a shellac varnish may be obtained by distilling approximately 50 cc. of varnish to dryness (avoiding decomposition of the shellac through excessive heat at the end) and determining the boiling range of this distillate by a redistillation. A portion of the final distillate may be diluted with water to ascertain if other solvents, such as naphtha or benzol, have been added. These will separate on dilution and the layer formed may be measured.

RELATION OF POUNDS OF SHELLAC PER GALLON TO SPECIFIC GRAVITY

WHITE SHELLAC VARNISH: DRY BLEACHED SHELLAC (5 PER CENT MOISTURE), DENATURED ALCOHOL, FORMULA NO. 1, 95-PER-CENT

SHELLAC, LB. PER GAL. OF ALCOHOL	SPECIFIC GRAVITY 16° C. (60° F.)	DEG. BAUMÉ	WEIGHT PER 1 GAL. VARNISH, LB.
3	0.9056	24.60	7.55
3.5	0.9167	22.70	7.64
4	0.9278	20.90	7.74
4.5	0.9375	19.33	7.79
5	0.9464	17.92	7.89
5.5	0.9530	16.90	7.95
6	0.9597	15.90	8.00

ORANGE SHELLAC VARNISH: TN SHELLAC (2 PER CENT MOISTURE), DENATURED ALCOHOL, FORMULA NO. 1, 95-PER-CENT.

3	0.900	25.55	7.50
3.5	0.9114	23.6	7.60
4	0.9228	21.7	7.69
4.5	0.9318	20.25	7.77
5	0.9395	19.0	7.83
5.5	0 9500	17.36	7.92
6	0.9554	16.53	7.97

NOTE 1.—Shellac varnishes will not always agree exactly with the specific gravity given above, estimated at 16° C. (60° F.). They will vary somewhat, due to more or less moisture and insoluble matter contained in the white and orange shellacs and also to loss of solvent by evaporation. However, the figures given agree closely with theoretical and practical results.

NOTE 2.—If 10 lb. of shellac is cut in 1 gal. of alcohol the yield is 2 gal. of varnish, hence 10 lb. of shellac cut in alcohol is equivalent to 1 gal.

Example.—

4 lb. shellac cut in 1 gal. alcohol yields 1.4 gal. varnish
4½ lb. " " " " " " " 1.45 " "
5 lb. " " " " " " " 1.50 " "

The following table shows corresponding percentages of gum and alcohol in shellac varnishes of the following pounds of gum cut per gallon, No. 1 Specially Denatured Alcohol 95-per-cent, by volume at 16° C. (60° F.)

POUNDS OF GUM PER GALLON OF ALCOHOL	GUM, PER CENT	ALCOHOL, PER CENT
3.0	30.68	69.32
3.25	32.41	67.59
3.50	34.05	65.95
3.75	35.61	64.39
4.0	37.11	62.89
4.25	38.54	61.45
4.50	39.90	60.10
4.75	41.20	58.80
5.0	42.45	57.55
5.25	43.65	56.35
5.50	44.79	55.21
5.75	45.89	54.11
6.0	46.98	53.02

The weight of 1 gal. of alcohol (No. 1 Special) at 16° C. (60° F.) is 6.7798 lb. according to Regulations No. 61, U. S. Internal Revenue.

The table given above is taken from the Official Booklet of the United States Shellac Importers' Association.

NOTE 3.—Method (*a*) covering Determination of Non-Volatile Matter in Varnish is the official method of the United States Shellac Importers' Association.

TENTATIVE METHOD OF TEST
FOR
SPECIFIC GRAVITY OF PIGMENTS[1]

Serial Designation: D 238 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

I. APPARATUS

Apparatus.

1. The apparatus shall consist of the following (see Fig. 1):

(*a*) A 100-cc. graduated flask, preferably with ground-glass stopper.

(*b*) A 100-cc. burette with a 75-cc. bulb in the upper part and the lower part (25 cc.) graduated in 0.05 cc.

(*c*) A balance accurate to 0.0001 g.

(*d*) A glass bell jar with a glass plate covered with a sheet of rubber.

(*e*) A laboratory water vacuum pump.

(*f*) A high vacuum pump.

NOTE.—The Nelson oil pump is satisfactory.

(*g*) Kerosine containing from 1 to 5 per cent of bodied linseed oil.

(*h*) An open-tube manometer, made of glass tubing 6 mm. in diameter, filled with mercury to approximately 86 cm., fitted with pressure tubing attached to a Y-tube leading to the bell jar and the pump.

NOTE.—The difference in levels of the mercury in the manometer when the system is in operation, subtracted from the barometer reading taken at the same time, gives the vacuum of the system in millimeters of mercury. The difference between the barometer and the manometer readings should not exceed 3 mm.

II. PROCEDURE

Standardization of Apparatus.

2. The flask shall be filled exactly to the mark with kerosine from the burette. The burette shall be allowed to drain for ten minutes, and the number of cubic centimeters, estimated to 0.01 or 0.02 cc., required to fill the flask shall be read. For convenience, a

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

burette and a flask should be chosen whose capacities are exactly equal after draining. This draining is important as in the operation of the method ample time is given for draining.

Method. 3. A quantity of the *dry* pigment to be tested shall be weighed into the graduated flask. This quantity in its dry state should practically fill the flask but should occupy a volume of less than 25 cc. after all air is expelled. Greater accuracy may be obtained with a large sample than with a small one. The burette shall be filled with the kerosine, and sufficient kerosine to cover the pigment shall be run into the flask from the burette. The flask shall be placed under the bell jar, which shall be attached to the water pump until the greater part of the air is expelled from the system. The removal of air may be hastened by shaking thoroughly several times, placing the flask under the vacuum after each shaking. The system shall then be closed with a stopcock or a pinchcock and the bell jar attached to the oil pump for the removal of the small amounts of air given off at the low pressures obtainable with the oil pump. The manometer is used to indicate whether the oil pump is giving the proper vacuum. When the air has all been removed, which is indicated by the cessation of bubbling, air is slowly admitted to the bell jar. The flask shall then be removed and filled to the mark from the burette. The height of liquid in the burette is noted to the nearest estimated hundredth after draining for one minute.

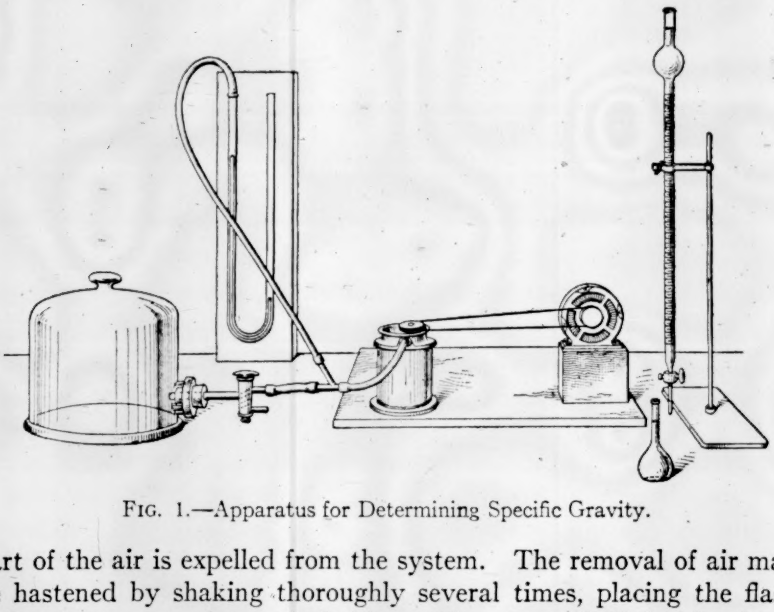

FIG. 1.—Apparatus for Determining Specific Gravity.

NOTE.—The removal of all the air can not be stressed too greatly, as the presence of air will cause low results.

Calculation.

4. The specific gravity shall be calculated from the formula:

$$\text{Specific gravity of pigment} = \frac{S}{K - X}$$

where

S = weight of pigment used;

K = volume of kerosine required to fill the flask when empty;

X = volume of kerosine required to fill the flask when the pigment is present.

Precautions.

5. The presence of low-boiling compounds in the kerosine will cause high results, due to the evaporation of these compounds, and for this reason a blank test with 100 cc. of the kerosine in a second graduated flask of the same dimensions should be run simultaneously with the sample of pigment (to ensure the same conditions as to pressure, temperature and time). Should there be any diminution in the volume of the liquid in the blank test, the flask shall be filled to the mark from the burette and the volume of liquid added shall be subtracted from the total volume of liquid required to fill the flask containing the pigment to the mark and the difference shall be used as the value of X in the above calculation.

6. Since the specific gravity of a pigment is only slightly affected by temperature, such variations as occur under normal conditions in a room would not materially affect the results. Care shall be taken, however, that the temperature of the liquid after transferring to the flask is approximately the same as it was when in the burette.

7. While kerosine has been found to be a good wetting medium, any liquid which does not have a high evaporation rate may be used. The liquids are interchangeable, as no constants on them need be determined. Hence, a pigment containing a dye which is slightly soluble in kerosine could be run with another liquid in the same apparatus without special standardization for that liquid. Operators are cautioned against the use of water as it causes considerable frothing with certain pigments.

8. Care shall be taken that the burette stopcock is well ground in order to prevent leakage of kerosine. Castor oil is suggested as the stopcock lubricant.

TENTATIVE METHOD OF TEST
FOR
ELASTICITY OR TOUGHNESS OF VARNISHES BY MEANS OF ADDITION OF LINSEED OIL[1]

Serial Designation: D 154 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. This method applies to varnishes which are less elastic or tough than zero Kauri reduction in the present Standard Methods of Testing Oleo-Resinous Varnishes (Serial Designation: D 154) of the American Society for Testing Materials.[2] The method of test is identical with the present test except that the $33\frac{1}{3}$-per-cent solution of Run Kauri in turpentine is replaced by a $66\frac{2}{3}$-per-cent solution of heat-bodied linseed oil for proportionately increasing the elasticity of the varnish under test.

PREPARATION OF STANDARD HEAT-BODIED LINSEED OIL

2. A high grade of alkali-refined linseed oil of an acid number of less than 1.0 shall be heated in an open kettle at a temperature of 300° C. ±5° C. (572° F. ±9° F.) until the viscosity of the oil after cooling shall be between 6 and 10 poises at 25° C.

STANDARD BODIED-OIL SOLUTION

3. A quantity of the bodied oil shall be reduced with one-half its weight of pure redistilled turpentine, using only that portion of turpentine distilling between 153 and 170° C. (308 to 338° F.).

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 105 York St., Brooklyn, N. Y.

This method, when adopted as standard, will be added to the present Standard Methods of Testing Oleo-Resinous Varnishes (Serial Designation: D 154 – 24), 1924 Book of A.S.T.M. Standards.

[2] 1924 Book of A.S.T.M. Standards.

PROCEDURE

4. The addition of the standard bodied-oil solution to the varnish, the flowing on panels, baking and bending shall be conducted exactly as in the Kauri reduction test described in the present Standard Methods D 154. In reporting results, the minimum percentage of the oil solution that must be added to the varnish, based on its non-volatile content, so the final mixture when flowed on tin and baked does not crack on the subsequent bending over a 3-mm. rod shall be reported.

TENTATIVE METHOD OF TEST
FOR
DISTILLATION OF GASOLINE, NAPHTHA, KEROSINE, AND SIMILAR PETROLEUM PRODUCTS[1]

Serial Designation: D 86 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1923, 1924, 1925, 1926.

APPARATUS

Flask. 1. *Flask.*—The Standard 100-cc. Engler flask is shown in Fig. 1, the dimensions and allowable tolerance being as follows:

	CENTIMETERS	INCHES	TOLERANCES, CM.
Diameter of bulb, outside	6.5	2.56	0.2
" " neck, inside	1.6	0.63	0.1
Length of neck	15.0	5.91	0.4
" " vapor tube	10.0	3.94	0.3
Diameter of vapor tube, outside	0.6	0.24	0.05
" " " " inside	0.4	0.16	0.05
Thickness of vapor tube wall	0.1	0.04	0.05

The position of the vapor tube shall be 9 cm. (3.55 in.) ±3mm. above the surface of the liquid when the flask contains its charge of 100 cc. The tube is approximately in the middle of the neck and set at an angle of 75 deg. (tolerance ±3 deg.) with the vertical.

Condenser. 2. *Condenser.*—The condenser (Fig. 2) consists of a $\frac{9}{16}$-in. (14.29 mm.) OD No. 20 Stubbs Gage seamless brass tube, 22 in. (55.88 cm.) long. It is set at an angle of 75 deg. from the perpendicular and is surrounded with a cooling bath 15 in. long (38.1 cm.), approximately 4 in. (10.16 cm.) wide by 6 in. (15.24 cm.) high. The lower end of the condenser tube is cut off at an acute angle, and curved downward for a length of 3 in. (7.62 cm.) and slightly backward so as to insure contact with the wall of the graduate at a point 1 to $1\frac{1}{4}$ in. (2.54 to 3.8 cm.) below the top of the graduate when it is in position to receive the distillate.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

Shield.

3. *Shield.*—The shield (Fig. 2) is made of approximately 22 gage sheet metal and is 19 in. (48.26 cm.) high, 11 in. (27.94 cm.) long and 8 in. (20.32 cm.) wide, with a door on one narrow side, with two openings, 1 in. (2.54 cm.) in diameter, equally spaced, in each of the two narrow sides, and with a slot cut in one side for the vapor tube. The centers of these four openings are 8½ in. (21.59 cm.) below the top of the shield. There are also three ½-in. (1.27 cm.) holes in each of the four sides with their centers 1 in. (2.54 cm.) above the base of the shield.

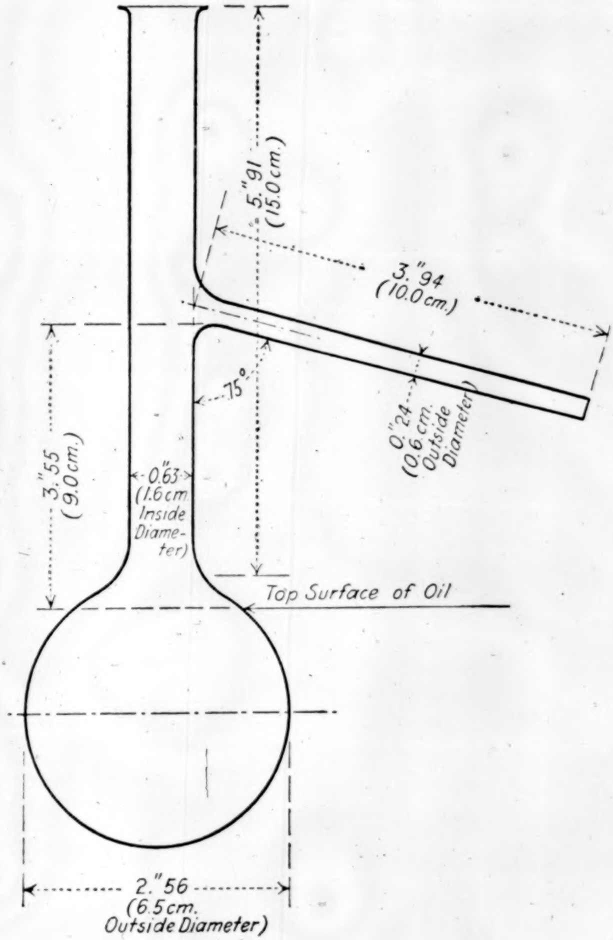
5."91
(15.0cm.)
3."94
(10.0cm.)
75°
0."24
(0.6cm.
Outside
Diameter)
3."55
(9.0cm.)
0."63
(1.6cm
Inside
Diameter)
Top Surface of Oil
2."56
(6.5cm.
Outside Diameter)

FIG. 1.

Support. 4. *Ring Support and Hard Asbestos Boards.*—The ring support is of the ordinary laboratory type, 4 in. (10.16 cm.) or larger in diameter, and is supported on a stand inside the shield. There are two hard asbestos boards: One 6 by 6 by $\frac{1}{4}$ in. (15.24 by 15.24 cm. by 6.35 mm.) with a hole $1\frac{1}{4}$ in. (3.175 cm.)[1] in diameter in its center, the sides of which shall be perpendicular to the surface; the other, an asbestos board to fit tightly inside the shield, with an opening 4 in. (10.16 cm.) in diameter concentric with the ring support. These are arranged as follows: The second asbestos board is placed on the ring and the first or smaller asbestos board on top so that it may be moved in accordance with the directions for placing the distilling flask. Direct heat is applied to the flask only through the $1\frac{1}{4}$-in. (3.175 cm.) opening in the first asbestos board.

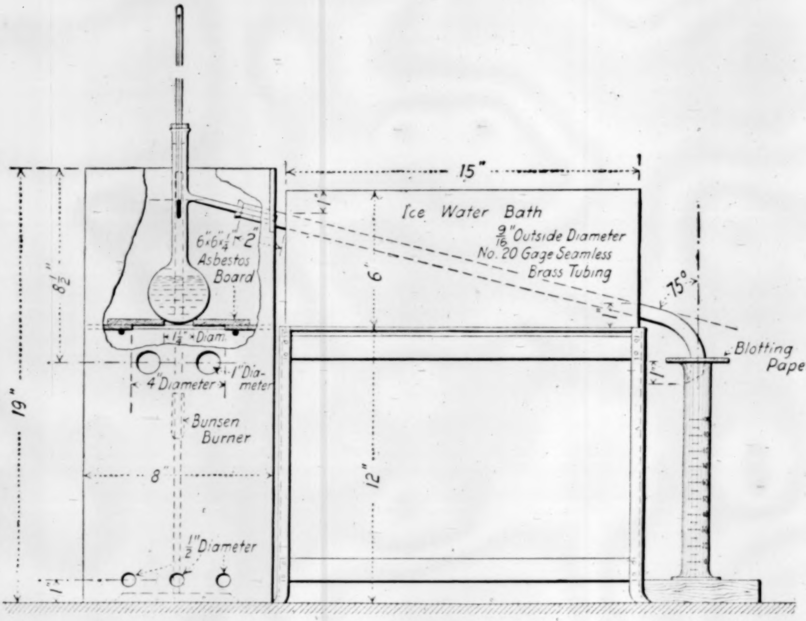
15"
Ice Water Bath
9/16" Outside Diameter
No. 20 Gage Seamless
Brass Tubing
75°
Blotting Paper
6"
12"
1"
19"
8 1/2"
6"×6"×1/4"×2"
Asbestos
Board
1 1/4" Diam.
1" Diameter
4" Diameter
Bunsen
Burner
8"
1/2" Diameter

FIG. 2.

Heater. 5. *Gas Burner or Electric Heater.*—

(*a*) *Gas Burner.*—The burner is so constructed that sufficient heat can be obtained to distill the product at the uniform rate specified below. The flame should never be so large that it spreads over a circle of diameter greater than 3½ in. (8.89 cm.) on the under surface of the asbestos board. A sensitive regulating valve is a necessary adjunct, as it gives complete control of heating.

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[1] When distilling petroleum products having an end point above 470° F. (243.34° C.), the hole in the asbestos board shall be $1\frac{1}{2}$ in. (3.81 cm.) in diameter.

(*b*) *Electric Heater.*—The electric heater, which may be used in place of the gas flame, shall be capable of bringing over the first drop within the time specified below when started cold, and of continuing the distillation at the uniform rate. The electric heater shall be fitted with an asbestos board top ⅛ to ¼ in. (3.175 to 6.35 mm.) thick, having a hole 1¼ in. (3.175 cm.) in diameter in the center. When an electric heater is employed, the portion of the shield above the asbestos board shall be the same as with the gas burner but the part below the board may be omitted.

Thermometers.

6. *Thermometers.*—

(*a*) The A.S.T.M. Low-Distillation Thermometer shall conform to the following requirements. These specifications cover a total-immersion thermometer graduated in either Centigrade or Fahrenheit degrees, as specified, the ranges being 0 to 300° C. or 30 to 580° F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 0 to 300° C. in 1° C. or 30 to 580° F. in 2° F.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).

STEM: Plain front, enamel back, suitable thermometer tubing.
Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

BULB: Corning normal or equally suitable thermometric glass.
Length, 10 to 15 mm. (0.39 to 0.59 in.).
Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 100 to 110 mm. (3.94 to 4.33 in.).

DISTANCE TO 300° C. OR 572° F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. Low Distillation," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale when the thermometer is standardized as provided below shall not exceed 0.5° C. or 1° F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50° C. or 100° F. up to 300° C. or 572° F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature of 280 to 290° C. or 540 to 560° F. for 24 hours, the accuracy shall be within the limit specified.

CASE: The thermometer shall be supplied in a suitable case on which shall appear The marking: "A.S.T.M. Low Distillation, 0 to 300° C." or "A.S.T.M. Low Distillation, 30 to 580° F." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

(*b*) The A.S.T.M. High-Distillation Thermometer shall conform to the following requirements. These specifications cover a total-immersion thermometer graduated either in Centigrade or Fahrenheit degrees, as specified, the ranges being 0 to 400° C. or 30 to 760° F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 0 to 400° C. in 1° C. or 30 to 760° F. in 2° F.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

BULB: Corning normal or equally suitable thermometric glass.
Length, 10 to 15 mm. (0.39 to 0.59 in.).
Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 25 to 35 mm. (0.98 to 1.38 in.).

DISTANCE TO 400° C. OR 752° F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. High Distillation" a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale up to 370° C. or 700° F. when the thermometer is standardized as provided below shall not exceed 1° C. or 2° F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50° C. or 100° F. up to 370° C. or 700° F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature between 360 and 370° C. or 680 and 700° F. for 24 hours, the accuracy shall be within the limit specified.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High Distillation, 0 to 400° C." or "A.S.T.M. High Distillation, 30 to 760° F." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

Graduate.

7. *Graduate.*—The graduate shall be of the cylindrical type, of uniform diameter, with a pressed or molded base and a lipped top. The cylinder shall be graduated to contain 100 cc., and the graduated portion shall be not less than 7 in. (17.78 cm.) nor more than 8 in. (20.32 cm.) long. It shall be graduated in single cubic centimeters and each fifth mark shall be distinguished by a longer line. It shall be numbered from the bottom up at intervals of 10 cc. The overall height of the graduate shall be not less than 9¾ in. (24.8 cm.), nor more than 10¼ in. (26.0 cm.). The graduations shall not be in error by more than 1 cc. at any point on the scale.

PROCEDURE

Procedure.

8. (*a*) The condenser bath shall be filled with cracked ice,[1] and enough water added to cover the condenser tube. The temperature shall be maintained between 32 and 40° F. (0 and 4.45° C.).

(*b*) The condenser tube shall be swabbed to remove any liquid remaining from the previous test. A piece of soft cloth attached to a cord or copper wire may be used for this purpose.

(*c*) One hundred cubic centimeters of the product shall be measured in the 100-cc. graduated cylinder at 55 to 65° F. (12.78 to 18.33° C.) and transferred directly to the Engler flask. None of the liquid shall be permitted to flow into the vapor tube.

(*d*) The thermometer[2] provided with a cork shall be fitted tightly into the flask so that it will be in the middle of the neck and so that the lower end of the capillary tube is on a level with the inside of the bottom of the vapor outlet tube at its junction with the neck of the flask. The thermometer shall be approximately at room temperature when placed in the flask.

(*e*) The charged flask shall be placed in the 1¼-in. (3.175-cm.) opening in the 6 by 6-in. (15.24 by 15.24-cm.) asbestos board with the vapor outlet tube inserted into the condenser tube. A tight connection may be made by means of a cork through which the vapor tube passes. The position of the flask shall be so adjusted that the vapor tube extends into the condenser tube not less than 1 in. (2.54 cm.) nor more than 2 in. (5.08 cm.).

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[1] Any other convenient cooling medium may be used.

[2] For products having an initial boiling point of 212° F. (100° C.) or higher, the High-Distillation Thermometer shall be used; for all other products, the Low-Distillation Thermometer shall be used.

(*f*) The graduated cylinder used in measuring the charge shall be placed, without drying, at the outlet of the condenser tube in such a position that the condenser tube shall extend into the graduate at least 1 in. (2.54 cm.) but not below the 100-cc. mark. Unless the temperature is between 55 and 65° F. (12.78 and 18.33° C.) the receiving graduate shall be immersed up to the 100-cc. mark in a transparent bath maintained between these temperatures. The top of the graduate shall be covered closely during the distillation with a piece of blotting paper or its equivalent, cut so as to fit the condenser tube tightly.

Distillation. 9. When everything is in readiness, heat shall be applied at a uniform rate, so regulated that the first drop of condensate falls from the condenser in not less than 5 nor more than 10 minutes. The distillation thermometer shall be read 2 minutes after heat is applied and the indication recorded as the "correction temperature." This figure is of significance only in cases when there is a question as to the accuracy[1] of the initial boiling point, as subsequently determined. When the first drop falls from the end of the condenser the reading of the distillation thermometer shall be recorded as the *initial boiling point.* The receiving cylinder shall then be moved so that the end of the condenser tube shall touch the side of the cylinder. The heat shall then be so regulated that the distillation will proceed at a uniform rate of not less than 4 nor more than 5 cc. per minute. The volume of distillate collected in the cylinder shall be observed and recorded, to the nearest 0.5 cc., when the mercury of the thermometer reaches each point that is an even multiple of 25° C. or the Fahrenheit equivalent of this point (50° C., 75° C., 100° C., 125° C., etc., or 122° F., 167° F., 212° F., 257° F., etc.). If preferred, the reading of

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[1] The initial boiling point is one of the observations which it is customary to report as indicative of the quality of gasoline. It is a point which is very difficult to check, especially when duplicate tests are made at different room temperatures, and it has not been found practical to devise an accurate method of correcting for this unavoidable variation in operating conditions. The practical significance of initial boiling point is not regarded as sufficient to warrant requiring that tests be conducted under regulated conditions of room temperature. The following directions are included as an expedient intended to obviate some of the difficulties that develop on account of the practice of including initial boiling point limits in specifications for the purchase and sale of gasoline:

If the "correction temperature" is below 70° F. (21° C.) or above 80° F. (27° C.), the observed initial boiling point, if it is below 150° F. (66° C.), may be considered incorrect by an amount not less than one third the difference between the "correction temperature" and 75° F. (24° C.). In case there is a dispute between buyer and seller, the observed initial boiling point figures obtained by all parties shall be revised according to the following formula:

$$\text{Revised initial boiling point} = \left\{\begin{matrix}\text{observed initial}\\ \text{boiling point}\end{matrix}\right\} - \frac{\text{Correction Temperature (deg. Fahr.)} - 75}{3}$$

If all of the revised figures fall within the specification limit the gasoline in question shall be considered as passing; otherwise arrangements shall, if possible, be made to conduct a distillation test with the room temperature maintained between the limits of 70 and 80° F. (21 and 27° C.) inclusive.

the distillation thermometer may be observed and recorded when the level of the distillate reaches each 10-cc. mark on the graduate. In case a product is being tested to ascertain whether or not it conforms with a given specification, all necessary observations shall be made and recorded, whether or not they are included in the series ordinarily employed by the laboratory making the test.

When the liquid residue in the distillation flask is approximately 5 cc. the heat may be increased because of the presence of heavy ends which have relatively high boiling points. However, no further increase of heat shall be applied after this adjustment. The 4 to 5-cc. rate can rarely be maintained from this point to the end of the distillation, but in no case shall the period between the point when approximately 5 cc. of liquid remains in the flask and the end point be more than 5 minutes.

The heating shall be continued until the mercury reaches a maximum and starts to fall consistently. The highest temperature observed on the distillation thermometer shall be recorded as the *maximum temperature* or end point. Usually this point will be reached after the bottom of the flask has become dry.

The total volume of the distillate collected in the receiving graduate shall be recorded as the *recovery*.

The cooled residue shall be poured from the flask into a small cylinder graduated in 0.1 cc., measured when cool and the volume recorded as *residue*.

The difference between 100 cc. and the sum of the recovery and the residue shall be calculated and recorded as *distillation loss*.

ACCURACY

Accuracy.

10. With proper care and attention to detail, duplicate results obtained for initial boiling point and maximum temperature, respectively, should not differ from each other by more than 6° F. (3.33° C.). Duplicate readings of the volume of distillate collected in the cylinder when each of the prescribed temperature points is reached should not differ from each other by more than 2 cc. In case observations are made on the basis of prescribed percentage points, the differences in temperature readings should not exceed the amounts equivalent to 2 cc. of distillate at each point in question.

CORRECTION FOR BAROMETRIC PRESSURE

11. The actual barometric pressure shall be ascertained and recorded, but no correction shall be made except in case of dispute.

In such cases the temperature points shall be corrected to 760 mm. (29.92 in.), by the use of the Sydney Young equation, as follows:

For Centigrade readings:

$$C_c = 0.00012\ (760-P)\ (273 + t_c)$$

For Fahrenheit readings:

$$C_f = 0.00012\ (760-P)\ (460 + t_f)$$

in which C_c and C_f are, respectively, corrections to be added to the observed temperature t_c or t_f, and P is the actual barometric pressure in millimeters of mercury.

The following table is a convenient approximation of the corrections as calculated by the above equation.

TEMPERATURE RANGE		CORRECTION[1] PER 10-MM. DIFFERENCE IN PRESSURE,	
DEG. CENT.	DEG. FAHR.	DEG. CENT.	DEG. FAHR.
10 - 30	50 - 86	0.35	0.63
30 - 50	86 - 122	0.38	0.68
50 - 70	122 - 158	0.40	0.72
70 - 90	158 - 194	0.42	0.76
90 - 110	194 - 230	0.45	0.81
110 - 130	230 - 266	0.47	0.85
130 - 150	266 - 302	0.50	0.89
150 - 170	302 - 338	0.52	0.94
170 - 190	338 - 374	0.54	0.98
190 - 210	374 - 410	0.57	1.02
210 - 230	410 - 446	0.59	1.06
230 - 250	446 - 482	0.62	1.11
250 - 270	482 - 518	0.64	1.15
270 - 290	518 - 554	0.66	1.19
290 - 310	554 - 590	0.69	1.24
310 - 330	590 - 626	0.71	1.28
330 - 350	626 - 662	0.74	1.32
350 - 370	662 - 698	0.76	1.37
370 - 390	698 - 734	0.78	1.41
390 - 410	734 - 770	0.81	1.45

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[1] To be added in case barometric pressure is below 760 mm.; to be subtracted in case barometric pressure is above 760 mm.

TENTATIVE METHOD OF ANALYSIS OF GREASE[1]

Serial Designation: D 128 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1922; Revised, 1924, 1926.

Scope. 1. These methods of analysis permit determinations sufficiently accurate for referee purposes of all the constituents of greases likely to be covered by specifications. These constituents are fillers and ash, soap bases, soap, fat, water, excess alkali or acid, petroleum products and unsaponifiable matter. No quantitative determination of glycerin is described, but a procedure is outlined for its qualitative detection.

I. SAMPLE.

Sample. 2. The size of sample for the soap determination (Methods (1) and (2) for Determination of Fillers, Soap, Fat, Petroleum Oil and Unsaponifiable Matter) shall be from about 8 to 30 g., depending on the consistency of the grease, which is chiefly determined by the percentage of soap present. Ten to twenty grams is usually a convenient amount for No. 3 Cup Grease, while thin transmission and other greases require a larger sample. The original sample should be stirred or mixed until uniform.

Accuracy of Weighing. 3. Samples need not be weighed more closely than 0.1 g.

II. SOLVENTS.

Petroleum Ether. 4. The petroleum ether shall have an end point not higher than 200° F., and 125 cc. of it shall not consume more than 0.2 cc. of 0.5 N potassium hydroxide when a blank test is made as follows:

One hundred and twenty-five cubic centimeters of petroleum ether shall be boiled with 10 cc. of 0.5 N alcoholic potassium hydroxide and 50 cc. of neutral 50-per-cent alcohol for $1\frac{1}{2}$ hours on a hot plate, using a glass tube of about 7 mm. internal diameter and 75 cm. long as a reflux condenser. After cooling, the solutions shall be titrated with 0.5 N hydrochloric acid and phenolphthalein. Not less than 9.8 cc. of 0.5 N acid shall be required for neutralization. The amount of alkali consumed in this test shall be deducted as a blank correction in the fat determination on solution (*E*).[1]

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

Alcohol. 5. The alcohol shall be prepared from commercial 95-per-cent grain or denatured grain alcohol by distilling from sodium hydroxide, diluting to 50 per cent (or 70 per cent) by volume with distilled water and neutralizing exactly with sodium or potassium hydroxide and phenolphthalein.

Phenolphthalein. 6. The phenolphthalein solution shall be prepared by dissolving 1.0 g. of phenolphthalein in 50 cc. of strong redistilled alcohol, adding 50 cc. of water, and neutralizing with sodium or potassium hydroxide.

Hydrochloric Acid. 7. Concentrated c.p. hydrochloric acid shall be used when "concentrated hydrochloric acid" is specified. Hydrochloric acid, 10-per-cent, shall contain 10 per cent by weight of absolute HCl, with a permissible variation of ± 0.5 per cent.

III. PROCEDURE.

(*A*) *Determination of Ash.*

NOTE.—The determination of the total ash should not in general be regarded as of any great importance. It is, however, sometimes required. This determination is often unsatisfactory on account of interaction between sodium carbonate derived from the soap, and inorganic fillers. There is always likelihood of reaction with the porcelain crucible itself on account of the long continued heating necessary to burn out all carbon. Moreover, if much sodium or potassium carbonate is present, the ash is fusible and often encloses carbon, making complete removal of the latter very difficult. Results will always be low in the presence of easily reducible oxides of volatile metals. There is also uncertainty as to when calcium carbonate has been completely ignited to calcium oxide. Ash determinations made on the same sample in different laboratories are likely to vary widely. For these reasons, it is usually preferable to make separate determinations of the percentage of fillers and of soap, from which data a calculation is easily made giving all the information to be gained from a direct determination of total ash.

8. The percentage of ash shall not be included in the total of the analysis.

(*1*) *Rapid Routine Method of Ash Determination.*

9. From 2 to 5 g. of grease shall be placed in a weighed porcelain crucible, and the sample weighed to the nearest 0.1 g. If lead or zinc soap is known to be absent, a platinum crucible is more convenient. The combustible matter shall be burned off slowly and the residue finally ignited until the ash is free of carbonaceous matter. The crucible and contents shall then be cooled in a desiccator and weighed, reporting the result as percentage of ash.

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[1] Solutions designated by capital letters in parentheses refer to the solutions given in Fig. 1.

(2) *Alternative Method of Ash Determination.*

10. The sample shall be burned as in method (1) until the ash is nearly free from carbon. The crucible and contents shall then be cooled, the soluble portions dissolved in a little water, and a slight excess of dilute sulfuric acid added, running the acid in carefully from a pipette inserted under a small watch glass covering the crucible. The crucible and contents shall then be warmed on the steam bath until effervescence has ceased. The watch glass shall then be rinsed with water into the crucible. The solution when tested with methyl orange for free acidity shall show free acid present. The contents of the crucible shall be evaporated to dryness, and the whole ignited at a low red heat, adding a few small pieces of dry ammonium carbonate to drive off the excess of sulfur trioxide. After cooling and weighing, the result shall be reported as "percentage of ash as sulfates." **Ash, Alternative.**

The alternative method gives more concordant results than the first method, but requires more time and manipulation.

(*B*) *Qualitative Examination of Ash.*

11. An easily fusible ash, dissolving completely in water to give a strongly alkaline solution, indicates a grease containing sodium, potassium, or both. A white infusible ash, practically insoluble in water, but imparting to it an alkaline reaction, may indicate calcium, with or without magnesium or aluminium. Zinc is shown by the yellow color of the ash while hot, and lead may be indicated by the presence of metallic globules, or by the yellow color of the ash when cold. **Detection of Bases.**

12. The ash shall be dissolved in dilute nitric or hydrochloric acid, and the presence of the several bases confirmed by suitable chemical tests, any standard scheme of qualitative analysis being followed.

(*C*) *Quantitative Examination of Ash.*

13. For the quantitative examination of ash any standard analytical procedure shall be used, the choice of methods being based on the information gained from the qualitative tests. If only one base is present, a quantitative determination is in general unnecessary.

(*D*) *Determination of Fillers, Soap, Fat, Petroleum Oil and Unsaponifiable Matter.*

14. Cup, fiber and sponge greases, with or without graphite, and all comparatively light colored greases, including axle greases, **Choice of Method.**

shall be examined by method (1). Dark greases containing residuum, asphaltic oils and asphalt, tars, etc., shall be examined by method (2), as these ingredients usually cause stubborn emulsions if a shaking-out process is applied at the start.

(1) *Determination of Filler, Soap, Fat, Etc.*

Determination of Filler.

15. If no fillers are present, Sections 15 and 16 shall be passed over and the grease sample introduced directly from a weighing bottle into a separator, the weight of the sample being obtained by difference. (See Section 2.) The sample shall then be shaken with 75 cc. of petroleum ether and 50 cc. of 10-per-cent hydrochloric acid until the grease is completely decomposed, after which Section 17 shall be followed. If fillers are present, the sample (See Section 2) shall be weighed in a small beaker, 50 cc. of 10-per-cent hydrochloric acid added and the beaker warmed on the steam bath, stirring until all soap lumps have disappeared and the upper layer is clear. If undissolved mineral matter or other filler is present, both layers shall be filtered through a Gooch crucible provided with a suitable mat, the beaker and crucible washed with water and petroleum ether, and the crucible finally washed with strong alcohol, collecting the alcohol washings separately and discarding them. The crucible and contents shall then be dried at 120° C. and weighed, and the result reported as "percentage of insoluble matter" (graphite, mica, talc, asbestos, gypsum, wood pulp, etc.)

Determination of Gypsum.

16. If gypsum is present as a filler, the results obtained in the determination described in Section 15 will be too low because of the solubility of calcium sulfate in hydrochloric acid. A sample of about 5 g. of grease shall be weighed in a small beaker, and decomposed with 50 cc. of petroleum ether and 25 cc. of concentrated hydrochloric acid, warming on the steam bath until all gypsum is dissolved. The contents of the beaker shall be cooled and poured into a separatory funnel, the beaker rinsed with water and a little petroleum ether and the solutions in the funnel allowed to separate clearly. The lower layer shall then be drawn into a beaker, and the petroleum ether in the separator washed with two portions of 20 cc. each of 10-per-cent hydrochloric acid, adding the washes to the strong acid solution in the separator. The hydrochloric acid solution in the beaker shall then be evaporated on the steam bath almost to dryness, diluted to 150 cc. with water, heated to boiling and treated with 10 cc. of 10-per-cent barium chloride solution. The barium sulfate shall then be filtered off and ignited in the usual way, and from the weight of the barium sulfate, the percentage of calcium sulfate shall be calculated, reporting it as $CaSO_4 \cdot 2H_2O$.

NOTE.—Chalk and other forms of alkaline earth carbonates are not determined by this method, but are considered under the determination of free alkalinity, Section 24.

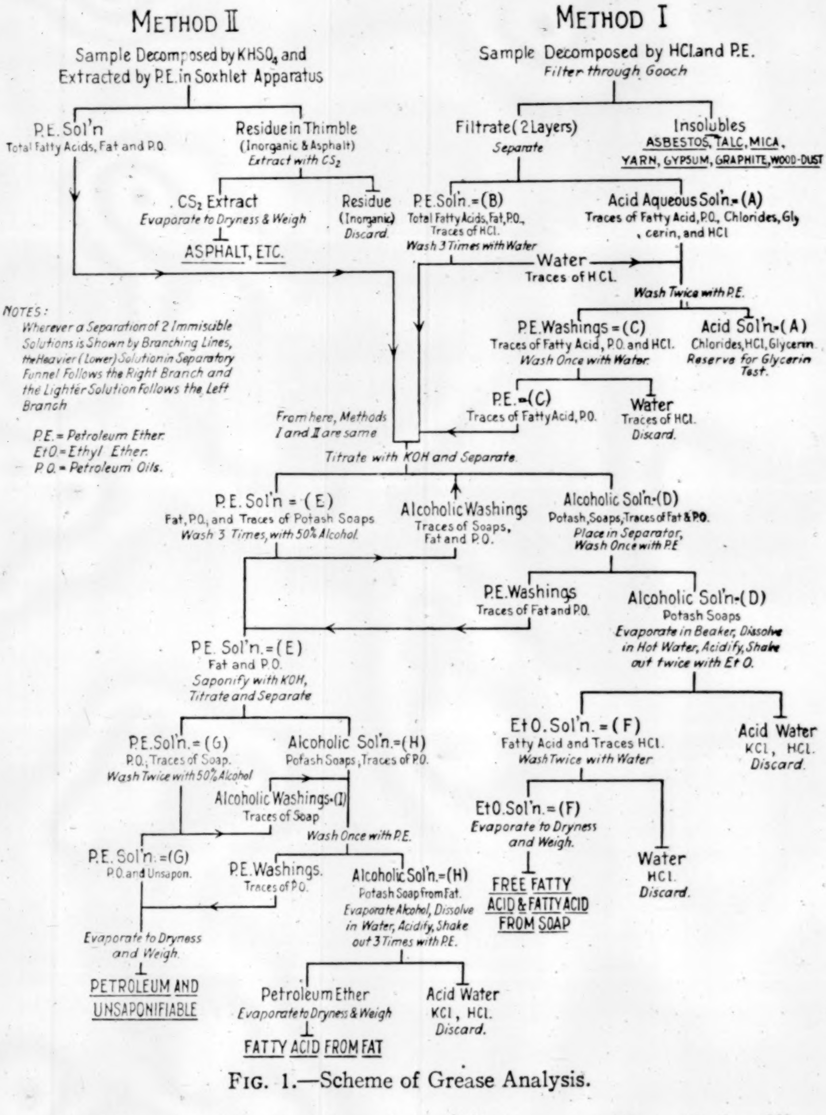
METHOD II
Sample Decomposed by KHSO$_4$ and Extracted by P.E. in Soxhlet Apparatus
P.E. Sol'n
Total Fatty Acids, Fat and P.O.
Residue in Thimble
(Inorganic & Asphalt)
Extract with CS$_2$
CS$_2$ Extract
Evaporate to Dryness & Weigh
ASPHALT, ETC.
Residue
(Inorganic)
Discard.
METHOD I
Sample Decomposed by HCl and P.E.
Filter through Gooch
Filtrate (2 Layers)
Separate
Insolubles
ASBESTOS, TALC, MICA, YARN, GYPSUM, GRAPHITE, WOOD-DUST
P.E. Sol'n. = (B)
Total Fatty Acids, Fat, P.O., Traces of HCl.
Wash 3 Times with Water
Acid Aqueous Sol'n. = (A)
Traces of Fatty Acid, P.O., Chlorides, Glycerin, and HCl
Water
Traces of HCl.
Wash Twice with P.E.
P.E. Washings = (C)
Traces of Fatty Acid, P.O. and HCl.
Wash Once with Water
Acid Sol'n. = (A)
Chlorides, HCl, Glycerin
Reserve for Glycerin Test.
P.E. = (C)
Traces of Fatty Acid, P.O.
Water
Traces of HCl.
Discard.
NOTES:
Wherever a Separation of 2 Immiscible Solutions is Shown by Branching Lines, the Heavier (Lower) Solution in Separatory Funnel Follows the Right Branch and the Lighter Solution Follows the Left Branch
P.E. = Petroleum Ether.
EtO = Ethyl Ether.
P.O. = Petroleum Oils.
From here, Methods I and II are same
Titrate with KOH and Separate
P.E. Sol'n = (E)
Fat, P.O., and Traces of Potash Soaps
Wash 3 Times, with 50% Alcohol.
Alcoholic Washings
Traces of Soaps, Fat and P.O.
Alcoholic Sol'n. = (D)
Potash, Soaps, Traces of Fat & P.O.
Place in Separator, Wash Once with P.E.
P.E. Washings
Traces of Fat and P.O.
Alcoholic Sol'n. = (D)
Potash Soaps
Evaporate in Beaker, Dissolve in Hot Water, Acidify, Shake out twice with Et O.
P.E. Sol'n. = (E)
Fat and P.O.
Saponify with KOH, Titrate and Separate
EtO. Sol'n. = (F)
Fatty Acid and Traces HCl.
Wash Twice with Water
Acid Water
KCl, HCl.
Discard.
P.E. Sol'n. = (G)
P.O., Traces of Soap.
Wash Twice with 50% Alcohol
Alcoholic Sol'n. = (H)
Potash Soaps, Traces of P.O.
Alcoholic Washings = (I)
Traces of Soap
Wash Once with P.E.
EtO. Sol'n. = (F)
Evaporate to Dryness and Weigh.
FREE FATTY ACID & FATTY ACID FROM SOAP
Water
HCl.
Discard.
P.E. Sol'n. = (G)
P.O. and Unsapon.
P.E. Washings.
Traces of P.O.
Alcoholic Sol'n. = (H)
Potash Soap from Fat.
Evaporate Alcohol, Dissolve in Water, Acidify, Shake out 3 Times with P.E.
Evaporate to Dryness and Weigh.
PETROLEUM AND UNSAPONIFIABLE
Petroleum Ether
Evaporate to Dryness & Weigh
FATTY ACID FROM FAT
Acid Water
KCl, HCl.
Discard.

FIG. 1.—Scheme of Grease Analysis.

Determination of Soap.

17. The solution resulting from the decomposition of the filler-free grease or the combined filtrate and washes from the determination of fillers (Section 15), except the alcohol, which is discarded, shall be placed in a separator, allowed to clear, and the aqueous layer (*A*),[1]

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[1] Solutions designated by capital letters in parentheses refer to the solutions given in Fig. 1.

which contains all the bases as well as glycerin, shall be drawn into another separator. The petroleum ether layer (*B*) shall be washed three times with 25cc. of water to remove hydrochloric acid, adding the washings to (*A*). Solution (*B*) shall then be run into a 250-cc. separator. The aqueous solution (*A*) shall then be washed twice with 20 cc. of petroleum ether (*C*), whereupon (*A*) is set aside for examination for glycerin (see Section 18). Solution (*C*) shall then be washed once with 15 cc. of water, which is rejected, and (*C*) shall be added to (*B*). If (*B*) and (*C*) are comparatively light colored, an approximate determination of free fatty acids and fatty acids from soap may now be made by titrating the solution in the separator with 0.5 *N* alcoholic potassium hydroxide and phenolphthalein, using 200 as the average neutralization value of the fatty acid (that is, 1.0 g. of fatty acid requires 200 mg. of absolute KOH for neutralization). If solutions (*B*) and (*C*) are dark, a few drops of phenolphthalein and sufficient 0.5 *N* alcoholic potassium hydroxide shall be added to make the alcoholic layer distinctly alkaline after vigorous shaking. If the solutions have been titrated, a slight excess of alkali shall be added before separating. The conservative addition of strong alcohol at this point may aid in securing rapid and sharp separation. The two solutions shall be allowed to separate sharply and the lower alcoholic layer (*D*) drawn off into another separator. The upper petroleum ether layer (*E*) shall be washed three times, with 30, 25 and 20 cc. of neutral 50-per-cent alcohol respectively, adding these washes to (*D*). Solution (*D*) shall be washed with 25 cc. of petroleum ether, after which (*D*) is drawn off into a beaker, and the petroleum ether added to (*E*). Solution (*D*) shall then be evaporated to a small volume to remove alcohol, the residue of potassium soap washed into a separator with hot water, acidified with hydrochloric acid and shaken out twice with 50 and 25 cc. of ethyl ether (*F*), respectively. Solution (*F*) shall be run into another separator and washed twice with 20-cc. portions of water, which is discarded. Solution (*F*) shall then be transferred to a weighed beaker and evaporated to dryness on the steam bath, blowing with air to remove all traces of petroleum ether. The residue consisting of free fatty acid and fatty acid from soap shall be heated for a short time on a steam bath, adding and evaporating 5 cc. of absolute alcohol to remove the last traces of water, and weighed. The exact neutralization value shall then be determined on as large a sample of these fatty acids as possible. From the total fatty acid found here, the free acid if any (see Sections 23 and 25) shall be deducted and the remainder calculated to percentage of soap, using the ash analysis as a guide in distributing the bases, if more than one are present.

The fatty acids may be identified to some extent by special tests, such as odor, crystal form, melting point, iodine number, neutralization value, color reactions, etc.

If the grease is appreciably oxidized, the fatty acids obtained by the ethyl ether extraction are likely to be dark in color and hard to identify. For further study and identification, the neutralized acids may be extracted again (qualitatively) with petroleum ether and dilute HCl, thus eliminating the small amount of more darkly colored matter.

Detection of Glycerin.

18. In case it is desired to determine whether a grease has been made from whole fats or from fatty acids, solution (*A*) shall be neutralized with dry sodium carbonate and sufficient excess added to precipitate calcium or other metals. The whole mass shall then be evaporated to dryness, the residue extracted several times with strong alcohol, the combined alcoholic extracts filtered, and the alcohol evaporated. The residue will then contain most of the glycerin, with a little sodium chloride. The presence or absence of glycerin in the residue shall be confirmed by suitable qualitative tests.

Since fats on saponification yield between 10 and 11 per cent of glycerin, and this analytical scheme does not include a quantitative determination of glycerin, the total percentages in greases made from fats should always be less than 100.

Determination of Fat.

19. The petroleum ether solution (*E*) (Section 17), containing free fat, petroleum oils, and unsaponifiable matter shall be concentrated to a volume of about 125 cc. in a 300-cc. Erlenmeyer flask, 10 cc. of 0.5 *N* alcoholic potassium hydroxide and 50 cc. of strong neutral alcohol added, and the whole boiled on a hot plate with an air condenser for 1½ hours. The uncombined alkali shall be titrated with 0.5 *N* hydrochloric acid, and from the alkali consumed, corrected for the blank determination as specified in Section 4, the percentage of free fat shall be calculated, using 195 as the average saponification value (that is, 1.0 g. of fat requires 195 mg. of absolute KOH for saponification.)

The titrated solution (*G*) shall be placed in a separator, the alcoholic lower layer (*H*) drawn off into another separator and the remaining traces of soap removed as described for (*B*) and (*C*), Section 17, making only two washes with 30 and 20 cc. of 50-per-cent alcohol (*I*). Solutions (*H*) and (*I*) shall be combined, washed once with a little petroleum ether, which is added to solution (*G*), and solutions (*H*) and (*I*) then evaporated to a small volume and the fatty acid isolated as described for (*D*), Section 17. The percentage of fat may be checked by weighing and titrating the free fatty acid.

Determination of Petroleum Oil.

20. The petroleum ether solution (*G*), now containing all the hydrocarbon oils and unsaponifiable matter shall be evaporated to dryness in a weighed beaker as described for (*F*), Section 17, the residue weighed, and the result reported as "petroleum oils plus unsaponifiable matter."

An approximate determination of the viscosity of the petroleum oil may be made by using a 2 or 5-cc. pipette, which has been standardized against oils of known viscosities. If a complete characterization of the petroleum products is required, a new sample of from 150 to 200 g. of grease shall be decomposed as described above, except that all quantitative operations shall be omitted, as well as the isolation of the free fatty acids, and the use of standard alkali and acid is not necessary.

If the grease contains rosin oil, beeswax, de gras, spermaceti, spermatin, montan wax, candle pitch, and other materials containing a large amount of unsaponifiable substances, the petroleum oils isolated from solution (*G*) will contain the unsaponifiable matter, and the constants found will differ from those of the petroleum products used in making the grease. In most cases, no further separation is possible except in the hands of skillful and experienced operators who can devise special methods to suit the individual conditions.

(*2*) *Determination of Filler, Soap, Fat, Etc.*

Method for Dark Greases.

21. The sample shall be weighed in a 3-in. porcelain dish, 10 g. of granulated acid potassium sulfate added and 10 g. of clean dry ignited sand. The dish and contents shall be heated on the steam bath with frequent stirring until all water is driven off, two hours usually being sufficient. After cooling and breaking up lumps with a small pestle, the mixture shall be transferred quantitatively to an extraction thimble, using a little petroleum ether to wash the last traces into the thimble, which should be already placed in a Soxhlet apparatus. The thimble shall be extracted thoroughly with petroleum ether, the extract concentrated somewhat if necessary, and the free fatty acid and fatty acid from soap titrated with 0.5 *N* alcoholic potassium hydroxide as in solutions (*B*) and (*C*), in method (1), Section 17. From this point on, the procedure is identical with that given in method (1), Sections 17, 19 and 20.

Determination of Asphalt and Tarry Matter.

22. The thimble shall be extracted a second time with carbon disulfide, the extract evaporated to dryness, heated for one hour to 120° C. and weighed, the results being reported as asphaltic and tarry matter. The residue in the thimble shall be discarded.

(*E*) *Determination of Free Alkali and Free Acid.*

23. From 10 to 30 g. of grease shall be weighed in a small beaker, dissolved as completely as possible in 75 cc. of petroleum ether by stirring with a spatula, the mixture washed into a 250-cc. Erlenmeyer flask with a small amount of petroleum ether, and the beaker rinsed with 50 cc. of 50-per-cent alcohol, the alcohol being poured into the flask, after which a few drops of phenolphthalein solution shall be added and the whole shaken vigorously. If the alcoholic layer, after settling for a few seconds, is pink, 10 cc. of 0.5 *N* hydrochloric acid shall be added, the solutions boiled on a hot plate for ten minutes to expel carbon dioxide, and the excess acid titrated back with 0.5 *N* alcoholic potassium hydroxide. The free alkalinity shall be calculated in terms of hydroxide of the predominating base. **Free Alkali.**

24. If chalk or any other form of alkaline earth carbonate, or lead carbonate, is present as a filler, it will be detected by effervescence on adding the hydrochloric acid. As the amount of such carbonates is likely to be considerable, the volume of 0.5 *N* hydrochloric acid added shall be increased sufficiently to dissolve all carbonate and leave a slight excess of acid. The solution shall be boiled for two minutes and the excess acid titrated back with 0.5 *N* alcoholic potassium hydroxide, and from the acid consumed, its equivalent in calcium carbonate, etc., shall be calculated, disregarding any other forms of alkalinity which may have been present. **Insoluble Carbonates.**

25. If the original alcoholic layer is not pink, the solution shall be titrated carefully in the cold with 0.5 *N* alcoholic potassium hydroxide, shaking well after each addition. The acidity shall be calculated as oleic acid. **Free Acid.**

26. If soaps of iron, zinc, aluminium, or other weak bases are present, a determination of free acid is not possible, since these metallic soaps react with potassium hydroxide. Up to the present, no means has been devised whereby this determination can be made directly.

(*F*) *Determination of Water.*

27. The quantity of water shall be determined in accordance with the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95) of the American Society for Testing Materials.[1] **Water.**

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[1] 1924 Book of A.S.T.M. Standards.

TENTATIVE METHOD OF TEST
FOR
PENETRATION OF GREASES[1]

Serial Designation: D 217 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Interpretation of Results. It should be understood that the original consistency of grease is determined by a variety of factors which are very difficult to control. The soap content is the most important single factor, but the kind of fats used, the method of mixing, the final water content, and the temperature of pouring are all very important in determining the final consistency, so that it is impracticable to maintain these consistencies within narrow limits. Any working of the sample after it is poured, or any remelting, will greatly change the consistency. The original consistency also changes to some extent on standing, changing most rapidly during the first 48 hours after manufacture and more slowly thereafter.

Although most tests in the past have been based on the original consistency of greases, this consistency bears no necessary relationship to the worked consistency which is the factor of practical importance for most uses of cup greases, etc. Tests on such greases should therefore be made on the worked consistency. It is also almost impossible to measure the unworked consistency when samples have to be taken from barrels or other large containers.

On the other hand, for very hard greases, such as railroad greases used in slab form, the original or unworked consistency is generally the property of practical importance and should be the object of the test.

Scope. 1. This method shall be used to measure the original consistency or the worked consistency of No. 0 cup grease and all harder greases.

2. The method should be applied only to greases which have not been melted after having been poured and cooled during manufacture.

I. APPARATUS

Penetrometer. 3. The penetration shall be measured on what is customarily known as an asphalt penetrometer such as that described in the Proceedings of the American Society for Testing Materials, Vol. VII, p. 626 (1907), and illustrated in Fig. 3 herein. It is desirable, however, to modify this penetrometer by placing a flat metal plate or

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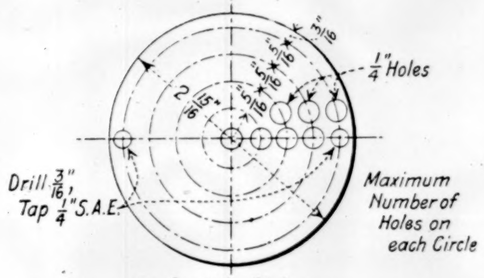
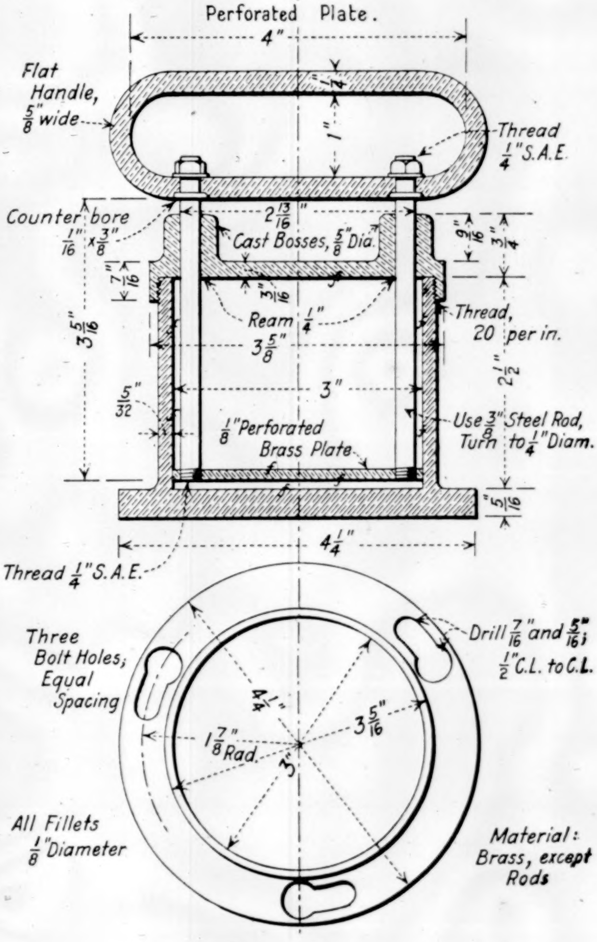
[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.


2 15/16"
5/16"
5/16"
5/16"
3/16"
1/4" Holes
Drill 3/16", Tap 1/4" S.A.E.
Maximum Number of Holes on each Circle

Perforated Plate.


4"
Flat Handle, 5/8" wide
1/4"
1"
Thread 1/4" S.A.E.
Counter bore 1/16" x 3/8"
2 13/16"
Cast Bosses, 5/8" Dia.
9/16"
3/4"
7/16"
3/16"
Ream 1/4"
Thread, 20 per in.
3 5/16"
3 5/8"
3"
2 1/2"
5/32
1/8" Perforated Brass Plate
Use 3/8" Steel Rod, Turn to 1/4" Diam.
5/16"
4 1/4"
Thread 1/4" S.A.E.
Three Bolt Holes; Equal Spacing
Drill 7/16" and 5/16"; 1/2" C.L. to C.L.
4 1/4"
1 7/8" Rad.
3 5/16"
3"
All Fillets 1/8" Diameter
Material: Brass, except Rods

Plan of Base.

FIG. 1.—Grease Worker.

transite board on top of the present grid base to give a flat support for the grease can. If many tests are to be made, it is preferable to replace the ordinary grid base with a special flat base 6 in. in diameter.

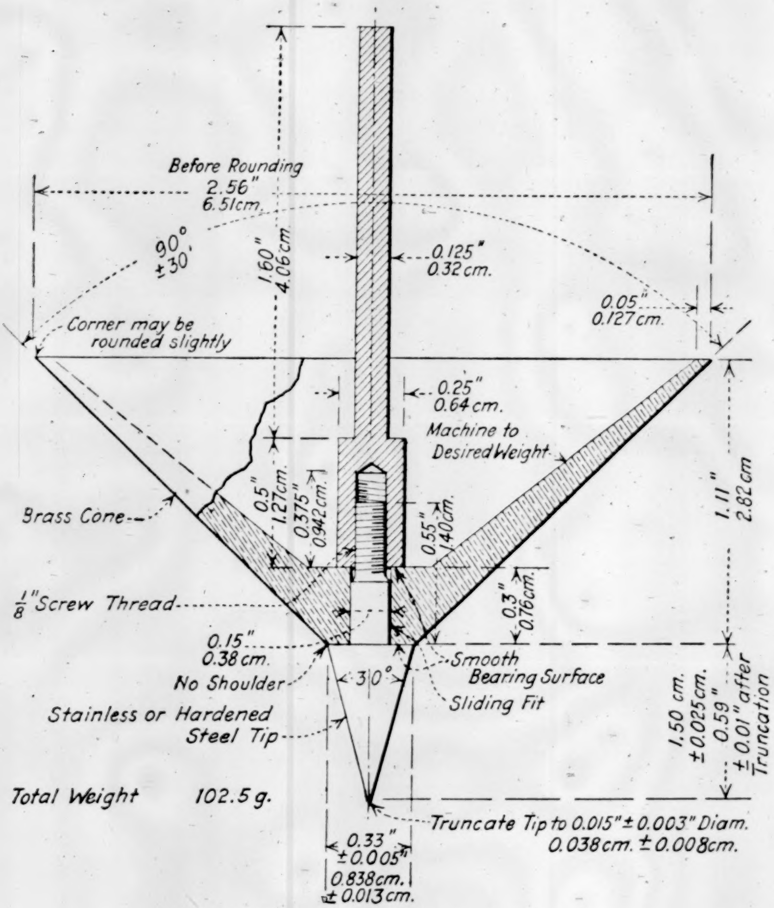

Before Rounding
2.56"
6.51cm.
90°
±30'
1.60"
4.06cm.
0.125"
0.32 cm.
0.05"
0.127 cm.
Corner may be rounded slightly
0.25"
0.64 cm.
Machine to Desired Weight
Brass Cone
0.5"
1.27cm.
0.375"
0.942cm.
0.55"
1.40cm.
1.11"
2.82 cm
1/8" Screw Thread
0.3"
0.76cm.
0.15"
0.38 cm.
No Shoulder
30°
Smooth Bearing Surface
Sliding Fit
Stainless or Hardened Steel Tip
1.50 cm.
±0.025cm.
0.59"
±0.01" after Truncation
Total Weight 102.5 g.
Truncate Tip to 0.015" ± 0.003" Diam.
0.038 cm. ± 0.008cm.
0.33"
±0.005"
0.838cm.
±0.013 cm.

FIG. 2.—Penetrometer Cone.

This plate should have a cork insert in the center to prevent dulling the tip of the cone if it should drop.

Cone and Plunger. 4. The needle used in the asphalt penetration tests shall be replaced with the cone shown in Fig. 2.[1] The cone shall be constructed of stainless steel or of brass with a detachable hardened steel or stainless steel tip and made in accordance with the outside dimensions and tolerances shown. The interior construction and dimensions without tolerances are intended to be suggestive only. The outside surface of the cone and tip shall be given a very smooth finish.

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[1] The cone may be combined with the asphalt plunger if desired, providing the total weight of cone and plunger and the outside dimensions of the cone are not thereby changed.

Weight.

5. The total moving weight in the test shall be 150 g. If the asphalt plunger weighs 47.5 g. (50 g. – 2.5 g. needle) the cone or the cone plus an attached weight must weigh 102.5 g. It is in general desirable to make the cone as light as possible so that it will have a wide range of usefulness, and to add a weight to give the desired total for the grease test. If the conditions of the tests are not specified, the penetration of a grease shall be understood to refer to the results of this test made at 77° F. (25° C.).

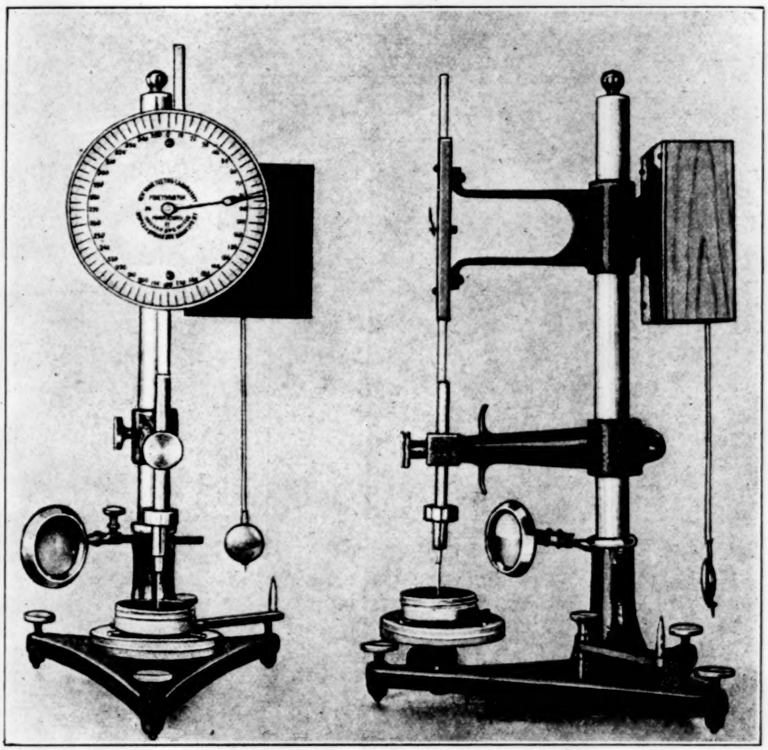

FIG. 3.—Penetrometer.

Grease Worker.

6. The grease worker shown in Fig. 1 shall be used to work the grease to constant consistency in tests where the worked consistency is to be measured.

Constant Temperature Bath.

7. A constant temperature bath regulated to 77° F. ±1° F. (25° C. ±0.5° C.) is desirable to bring the samples to the temperature of test if many tests are to be made.

II. SAMPLES

8. Tests on the unworked consistency of grease shall be made only on grease in the original container (or cake in the case of very hard greases), 1-lb. tins being especially convenient for the purpose. If samples are to be taken from large containers, the tests must be made only on a sample worked as specified below. In taking samples from large containers, any discolored layers near the surface shall first be completely cut away and rejected.

III. PROCEDURE

(*A*) *Original* (*Unworked*) *Consistency*

Bringing to Temperature of Test.

9. The temperature of the sample shall be brought to within 1° F. (0.5° C.) of 77° F. (25° C.) before the test. If the sample is initially within 3 to 4° F. (1.5 to 2° C.) of this temperature, it can be brought to 77° F. (25° C.) by placing in a water bath for 30 or 40 minutes, but if the initial temperature is outside this range it must be placed in the constant temperature bath for 1½ hours to insure reaching the final constant temperature. If the room temperature is more than 3 to 4° F. (1.5 to 2° C.) from 77° F. (25° C.) a lid should be placed on the can, sealing with grease to prevent the entrance of water and the can immersed in the bath for the required period as, otherwise, the temperature of the surface will be different from that of the main body of the grease. Any holes or seams in the can should also be sealed with grease or paraffin.

Preparation of Sample.

10. The surface of the grease shall be cut level and very smooth with a knife. Care must be taken not to work the surface of the grease. Any crust or discolored layers shall be completely removed before testing.

Procedure.

11. The can of grease shall be placed on the penetrometer table and the cone lowered until the tip just touches the surface. Watching the shadow of the tip aids in accurately setting the cone. The scale shall then be set to zero and the plunger released suddenly and kept released for five seconds. The penetration is read from the scale (the units being tenths of a millimeter) by the same procedure as is customary in measuring asphalt penetration as described in the Standard Method of Test for Penetration of Bituminous Materials

(Serial Designation: D 5) of the American Society for Testing Materials.[1]

Spacing of Tests in Cans.

12. In making tests, the total surface area disturbed by the test has a diameter about equal to the measured depth of penetration. In order to prevent one test from being affected by another disturbed area or by sides of the can, in starting a test the tip shall never be placed closer to the sides of the can or the edge of a previous hole than the penetration distance of that particular grease. The grease shall not be smoothed over for further tests.

Number of Tests Required.

13. Five tests shall be made on each sample and the average reported as the consistency, if the mean deviation of these readings does not exceed 3.0 per cent. If the mean deviation does exceed 3.0 per cent, the average of ten readings shall be reported as the consistency of the sample. More than one 1-lb. can will be needed for the required number of tests on the softer greases.

(*B*) *Procedure for Worked Consistency*

Procedure for Worked Consistency.

14. The procedure for worked greases shall be the same as that for unworked consistency except that the grease to be tested shall be transferred to the worker, which shall be filled heaping full with a minimum inclusion of air, brought to within 2° F. (1° C.) of 75° F. (24° C.) and worked with 60 double strokes of the plunger.[2] The top and plunger can then be removed, the surface smoothed over and the test made at once, if the temperature is within 1° F. (0.5° C.) of 77° F. (25° C.). As soon as one test is made, the surface may be smoothed over for the next, taking care to avoid creating air pockets. If desired, the grease may be transferred carefully to another container before bringing to 77° F. (25° C.) and testing. One 1-lb. sample is sufficient for all tests.

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[1] A.S.T.M. Standards Adopted in 1925.

[2] In general quite similar results may be obtained by working the grease thoroughly for five minutes with a spatula on a flat plate, providing care is taken to prevent working in much air. For referee tests, however, the standard worker must be used.

TENTATIVE METHOD OF TEST
FOR
BURNING QUALITY OF LONG-TIME BURNING OIL FOR RAILWAY USE[1]

Serial Designation: D 219 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope. 1. The burning test for long-time burning oil is intended for the determination of the burning quality of special kerosine oil used in railway semaphore signal lamps.

I. APPARATUS

Lamp. 2. The lamp shall be the standard American Railway Association, Signal Section, semaphore lamp.

Font. 3. A 31 fluid ounce font, about 3 in. high, measured from inside the bottom to top of burner collar, and fitting the standard lamp, shall be used.

Burner. 4. The burner shall be a *Dressel No. 23 Long-Time Burner*, New York Central Type, or any other burner meeting the following requirements: A nickel plated long-time burner made of suitable weight metal, provided with the conventional wick adjusting device, with any convenient means of fitting to font, and in other respects corresponding to the following requirements:

Flame Spreader.—Cylindrical, $\frac{5}{16}$ in. in height and $\frac{1}{2}$ in. in inside diameter, soldered to the top of wick tube. Two V-shaped slots, placed opposite to each other, with top of V $\frac{1}{4}$ in. wide and bottom ending just above top of wick tube.

Wick Tube.—1$\frac{15}{16}$ in. in length, $\frac{1}{4}$ in. in inside diameter, and extending $\frac{5}{8}$ in. above top of wick tube.

Chimney Support Ring.—1$\frac{1}{4}$ in. in inside diameter, $\frac{7}{16}$ in. below top of flame spreader, equipped with 4 springs to hold chimney in place.

Air Vents.—Four $\frac{1}{16}$ in. holes placed symmetrically in flame spreader just above the top of the wick tube; four rectangular openings, $\frac{7}{16}$ in. high, by $\frac{9}{16}$ in. wide, placed below the chimney support ring and between the chimney springs.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

Chimney. 5. The chimney shall be a No. 55 D Chimney,[1] or any other chimney meeting the following requirements: Straight wall glass $2\frac{1}{2}$ in. high and $1\frac{1}{8}$ in. in inside diameter, with rim at top and bottom.

Wick. 6. A new gray round felt wick, approximately $7\frac{3}{4}$ in. long and $1\frac{3}{16}$ in. in diameter, made by sewing a strip of felt $\frac{1}{2}$ in. wide by $7\frac{3}{4}$ in. long by $\frac{1}{8}$ in. thick into proper form is suitable. The wick shall be washed with redistilled ether and dried at room temperature before use.

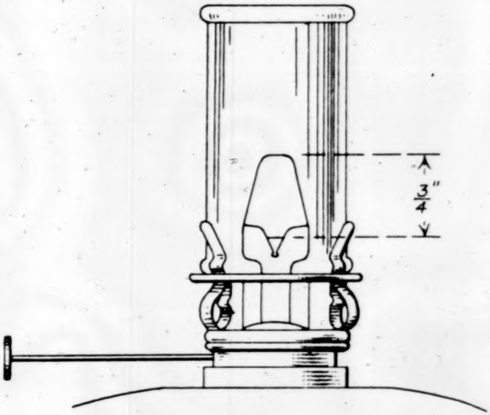

FIG. 1.

Balance. 7. A platform balance sensitive to 1 g. shall be used.

Room. 8. The lamp may be burned in any well ventilated room, or out of doors, if not subjected to the direct rays of the sun.

Sight Gage. 9. A sight gage, or other suitable flame measuring device, accurate to $\frac{1}{16}$ in. shall be used. The sight gage shown in Fig. 2 is satisfactory.

II. PROCEDURE

Procedure. 10. Seven hundred and fifty cubic centimeters of the oil to be tested shall be placed in the font. The burner, wick, chimney and font shall be assembled, the rough edge trimmed from the wick and the wick centered in the flame spreader, lighted and adjusted to give a flame $\frac{3}{4}$ in. high, measured from top of wick. This, and all following flame measurements, should be made with the assembly inside of the lamp, with slide open, and in a room free from drafts.

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[1] This term, "55-D Chimney," is fully descriptive with glass manufacturing companies as the long-time burner chimney covered by these specifications.

The flame should have a flat top and be of the general shape indicated in Fig. 1. If this cannot be accomplished by leveling the lamp, the burner should be rejected. Inability to secure the specified flame shape will be due, in such cases, to improper alignment of the sides of the flame spreader. It is essential that the specified flame shape be adhered to, as any deviation from it may influence the rate of oil consumption and the flame drop. The assembly shall be weighed while burning, then placed in the lamp. The wick shall be readjusted, if necessary, without removing the font from the lamp, during the first four hours. The lamp shall be allowed to burn continuously for the duration of the test. After 96 hours, the font assembly shall be removed from the lamp, weighed while burning and then replaced in the lamp. After 120 hours the lamp shall again be weighed and the

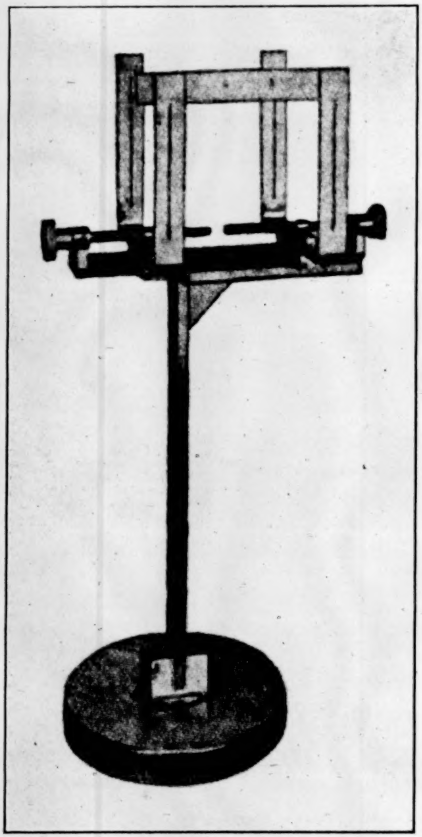

FIG. 2.—Sight Gage.

average rate of oil consumption per hour calculated for the 96 to 120-hour period. From this rate and the original weight of oil in the font, the number of additional hours required to make the total quantity of oil consumed 650 cc. shall be calculated and the lamp burned the calculated length of time. The oil consumption shall be verified by weighing at the end of the test. The time required to burn 650 cc. will, in general, be not less than 120 hours and not more than 144 hours if proper attention is paid to initial flame height and shape. At the end of the test, observe and record the change in height of flame, and condition of the wick and chimney.

TENTATIVE METHOD OF TEST
FOR
BURNING QUALITY OF MINERAL COLZA OIL[1]

Serial Designation: D 239 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. The burning test for mineral colza oil is intended for the determination of the burning quality of the special illuminating oil known to the trade as mineral seal oil, 300 oil or mineral colza oil, used in railway coach lamps.

I. APPARATUS

Lamp. 2. The lamp shall be the standard Dressel No. 520 Side Lamp fitted with a No. 3 Dual Burner without spring chimney holder and without smoke bell.

Font. 3. A 24-fluid-oz. font having the following measurements shall be used:

	Inches	Centimeters	Tolerances, cm.
Inside diameter of burner opening	1.39	3.52	±0.01
Outside diameter of font at bottom	3.74	9.49	....
Outside diameter of font above constriction	4.06	10.32	....
Outside diameter of font at widest point	4.50	11.43	....
Outside diameter of font at neck	1.85	4.69	....
Height of font (to top of collar)	4.31	10.95	....
Height of font (to outside edge top)	3.65	9.27	0.08
Diameter of inside compartment	1.89	4.80	....
Thickness of metal	0.03	0.07	....

Burner. 4. The burner shall be a Dressel "D" or No. 3 Dual Burner, without skirt, or any other burner meeting the following requirements:

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

	INCHES	CENTIMETERS	TOLERANCES, CM.
UPPER PART OF BURNER:			
Thickness of metal, No. 24 B. & S. gage.			
Height of cone from base of cone:			
(1) Center	1.61	4.09	0.03
(2) 1 cm. to right of center	1.57	3.98	0.03
(3) 1 cm. to left of center	1.56	3.97	0.05
Inside diameter of cone at base	2.05	5.20	....
Inside diameter of cone at constriction	2.00	5.08	....
Inside diameter of cone at base of flame spreader slot:			
(1) Parallel to slot	1.49	3.79	0.01
(2) Perpendicular to slot	1.52	3.85	0.01
Height of collar	1.95	4.96	....
Holes near base of cone, 18 in number:			
(1) Diameter	0.11	0.27	....
(2) Spacing edge to edge	0.13	0.33	....
(3) Spaces at sides of cone (without holes)	0.78	1.98	....
Width of flame spreader slot:			
(1) Center	0.31	0.78	0.02
(2) 1 cm. to right of center	0.31	0.78	0.02
(3) 1 cm. to left of center	0.31	0.78	0.02
Ventilating openings, 40 in number in each row:			
(1) Top row (diamond shaped), height and width	0.13	0.33	....
(2) Second row (circular shaped) diameter	0.09	0.22	....
(3) Third row (diamond shaped) height and width	0.13	0.33	....
(4) Fourth row (circular shaped) diameter	0.09	0.22	....
(5) Bottom row (diamond shaped):			
Height	0.22	0.55	....
Width	0.11	0.28	....
LOWER PART OF BURNER:			
Diameter of widest point	2.31	5.87	....
Diameter at narrowest point (just below screen)	1.28	3.26	....
Diameter at bottom (thread)	1.40	3.55	....
Top of screen (outer edge) to bottom of burner	1.65	4.19	0.06
Top of wick holder to top of screen	0.91	2.30	0.08
Holes in screen:			
(1) Outer circle, 36 in number, diameter	0.11	0.27	....
(2) Second circle, 36 in number, diameter	0.11	0.27	....
(3) Inner circle, 36 in number, diameter	0.07	0.17	....
Space between wick holders	0.11	0.27	0.04
Wick holders:			
(1) Width (outside)	1.18	3.00	....
(2) Depth (outside)	0.19	0.48	0.06
(3) Length	2.54	6.44	0.02
Wick holder brace:			
(1) Width (outside)	1.02	2.60	....
(2) Depth (outside)	0.15	0.38	....

FOLLOWING MEASUREMENTS TAKEN WITH UPPER PART OF BURNER FITTED EVENLY AND TIGHTLY ON LOWER HALF:

	INCHES	CENTIMETERS	TOLERANCES, CM.
Top of wick holder to base of flame spreader slot	0.32	0.81	0.03
Base of flame spreader slot (inside) to edge of wick holder (outside)	0.13	0.34	0.04
Height of burner (overall)	3.24	8.23	0.03

Chimney. 5. The chimney shall be a Keystone No. 24 Chimney, or any other chimney meeting the following requirements:[1]

	INCHES	CENTIMETERS	TOLERANCES, CM.
Total height	9.94	25.24	....
Diameter at top	1.60	4.06	0.02
Diameter at a point 1.75 in. (4.44 cm.) from top	1.60	4.06	0.02
Diameter at a point 5 in. from top	2.60	6.60	....
Diameter at widest point	3.58	9.10	....
Diameter at the bottom	2.55	6.47	0.03
Distance from bottom to widest point	2.69	6.78	0.11
Distance from bottom to constriction near bottom	0.94	2.38	....
Thickness of glass at top	0.06	0.14	0.01
Thickness of glass at bottom	0.05	0.12	0.03

Wick. 6. The wicks shall be the American "D" Dual Wick and shall be used as received from the manufacturer. New wicks shall be used in each test.

Balance. 7. A platform balance sensitive to 0.1 g. shall be used.

Room. 8. The lamp shall be burned in a well-ventilated room, free from draughts, and not subjected to the direct rays of the sun. The lamp shall be mounted on a wall, at a distance of approximately 2¼ in. from the wall, by means of a bracket provided with the lamp.

Sight Gage. 9. A sight gage, or some other suitable flame measuring device, accurate to $\frac{1}{16}$ in. shall be used. The instrument illustrated in Fig. 2 of the Tentative Method of Test for Burning Quality of Long-Time Burning Oil for Railway Use (Serial Designation: D 219 - 26 T) of the American Society for Testing Materials[2] is satisfactory.

II. PROCEDURE

Setting the Lamp. 10. Place approximately 600 cc. of the oil to be tested in a clean font. The wicks, wetted with the oil, shall be inserted in the burner and then assembled with the font and chimney. The wicks shall then be trimmed with scissors so that they are of the same height and so as to produce a flame which, unless otherwise specified, shall be $1\frac{1}{16}$ in.

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[1] All measurements are outside.

[2] See p. 840.

high measured from the top of the wick guide, and $1\frac{3}{8}$ in. wide at its widest point. The trimming shall be done very carefully to produce a flame free from peaks or ears and the lamp should be lit and the flame frequently inspected during the course of the trimming in order to determine the conditions of the flame as to size and shape. Proper height can be obtained by turning up or down, and the proper width by trimming the corners of the wick. These adjustments shall be made to $\pm\frac{1}{16}$ in. from the standard flame. After the proper flame has been obtained, the burner and wicks shall be removed, the wicks dried as thoroughly as possible without removing the wicks from the burner and the apparatus assembled with a clean font and chimney. Weigh the assembly and then pour exactly 600 cc. of the sample into the font, then light the lamp and weigh again while burning. After 1 hour, the flame shall be measured and adjusted if necessary to the proper height and width. Allow the lamp to burn continuously until 570 cc. of oil have been consumed, as determined by weight. In general, 570 cc. of oil will be consumed in not less than 20 hours. At the end of the test, record the number of hours burned, the flame change and the condition of wick and chimney.

TENTATIVE METHOD OF TEST
FOR
SULFUR IN NAPHTHAS AND ILLUMINATING OILS[1]

Serial Designation: D 90 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1924, 1926.

Scope. This method is intended to be applied to illuminating oils and petroleum naphthas. It is not applicable to mixtures containing carbon bisulfide.[2]

APPARATUS.

Absorber of chemically resistant glass, about 150-cc. capacity, containing glass beads or short pieces of glass rod in the suction side as shown.

Chimney of chemically resistant glass connected with the absorber by a rubber stopper.

Spray trap of chemically resistant glass connected with the absorber by a rubber stopper.

Small lamp of about 25-cc. capacity. This lamp may conveniently consist of a 25 to 35-cc. Erlenmeyer flask and a cork carrying a short section of glass tubing, about $\frac{1}{8}$ in. in inside diameter. The cork must be grooved along the sides so that air may enter the flask while the oil is being consumed.

Ordinary cotton wicking.

Filter pump or other means for continuous suction and rubber tubing to connect with spray trap.

SOLUTIONS REQUIRED.

Hydrochloric acid.—Solution containing 2.275 g. HCl per liter and carefully checked for accuracy.

Sodium carbonate.—Solution containing 3.306 g. Na_2CO_3 per liter. Exactly 10.0 cc. should be required to neutralize 10.0 cc. of the hydrochloric acid solution.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

[2] If high volatility motor fuels are tested by this method, and especially if they contain benzol, it is very important that the suction be regulated so that the height of the flame is not more than $\frac{1}{4}$ in.

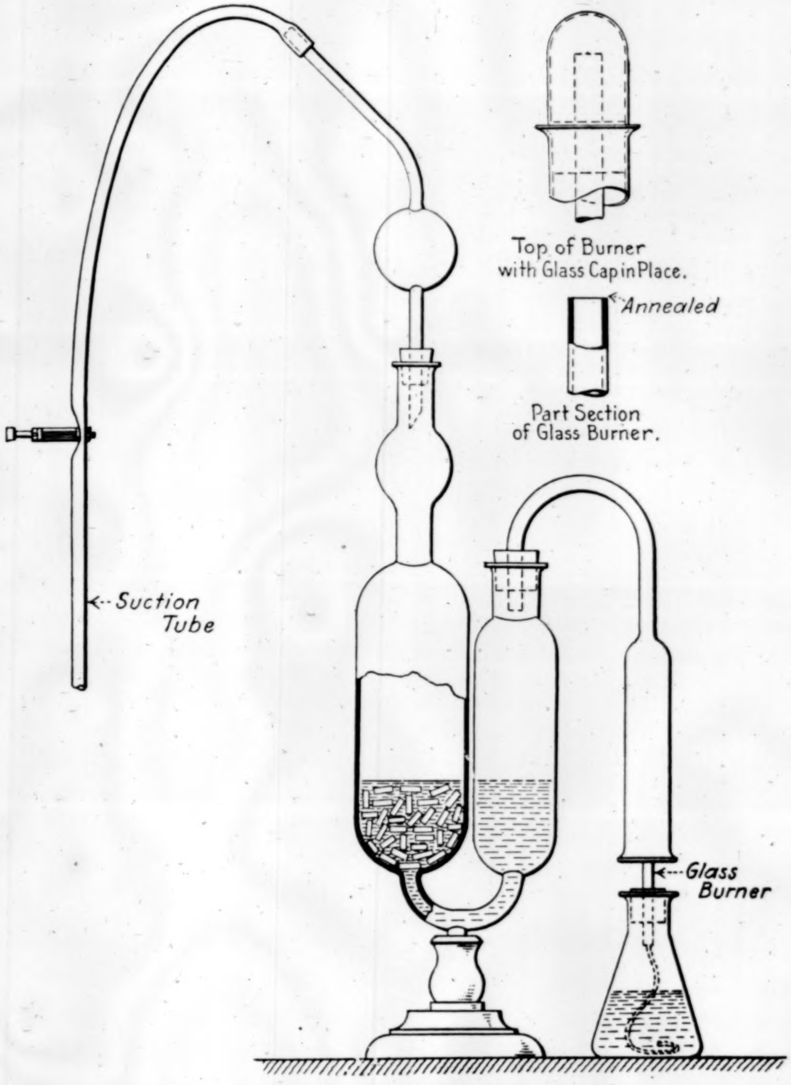
Top of Burner
with Glass Cap in Place.
Annealed
Part Section
of Glass Burner.
Suction
Tube
Glass
Burner

FIG. 1.—Apparatus for Determination of Sulfur in Oils.

Methyl orange.—Solution in distilled water, containing 0.004 g. methyl orange per liter.

PROCEDURE.

Pass two strands of new cotton wicking about 4.5 in. long through the $\frac{1}{8}$-in. diameter wick tube so that they are not twisted but parallel in the wick tube. Trim the wick with very sharp scissors. Pour into the clean dry lamp about 20 cc. of the oil to be tested, insert the wick and cork and weigh the assembly with an accuracy of 0.001 g. It is advisable to make a blank determination at the same time and under the same conditions by burning sulfur-free alcohol in a similar lamp.

Rinse out the absorber containing the glass beads thoroughly with distilled water and add exactly 10.0 cc. of the standard sodium carbonate solution from an accurately calibrated burette, allowing the burette to drain for three minutes before taking the reading. Rinse the chimney and the spray trap with distilled water, dry the chimney and connect both to the absorber as shown in Fig. 1. Set up the apparatus for the blank determination in exactly the same manner and using exactly 10.0 cc. of the sodium carbonate solution. Apply gentle suction to both absorbers, light both the weighed oil lamp and alcohol lamp and then place in position under the chimneys so that the tops of the wick tubes extend into the chimneys not more than $\frac{1}{16}$ in. Adjust the wick height and the suction so that the flame is steady, free from smoke and approximately $\frac{1}{4}$ in. high. This requires that the wick be flush with the top of the wick tube for naphthas and a little higher for illuminating oils. The room must be free from drafts. The suction on the blank should be so adjusted that air is drawn through both determinations at the same rate. Continue burning for about two hours, or less if the sulfur content of the oil is high. During this time the oil should be consumed at the rate of about 1 g. per hour.

Extinguish the flames and stop the suction on both absorbers. Weigh the oil lamp immediately and calculate by difference the weight of oil consumed. Working with the blank first, disconnect the spray trap and chimney and wash them thoroughly with the methyl orange solution, using a wash bottle with a very fine jet and collecting the washings in the absorber. The amount of solution required for washing should not exceed 35 cc. Carefully titrate the very faintly yellowish solution in the absorber with standard HCl, added to the suction side of the absorber from an accurately calibrated burette. During this titration, the contents of the absorber should be agitated carefully, either by blowing through a rubber tube held between the operator's lips and connected at the other end with the chimney side of the absorber or else by the use of a suitable rubber syringe bulb. As the end point is approached, draw the liquid back into the chimney side between each addition of acid and then blow it into the suction side, agitating as before. As soon as the first permanent pink color appears, the end point has been reached. Read and record the volume of HCl solution used.

Rinse the chimney and spray trap used in the actual determination into the absorber to which they were connected, exactly as prescribed for the blank. If the methyl orange solution in the absorber has a pink color, too much oil has been burned and the determination must be repeated, burning for a shorter time. Titrate just as in the blank, making sure that the absorber is cold. Read and record the volume of HCl solution required.

Calculate the sulfur content of the oil by substituting the proper values in the following formula:

$$\text{Percentage of Sulfur} = \frac{(\text{HCl for blank, cc.} - \text{HCl for sample, cc.}) \times 0.1}{\text{grams of oil burned}}$$

If a blank is not run, the formula is:

$$\text{Percentage of Sulfur} = \frac{(\text{Na}_2\text{CO}_3\text{, cc.} - \text{HCl, cc.}) \times 0.1}{\text{grams of oil burned}}$$

These formulas are correct only for the standard solutions specified, 1 cc. of each being equivalent to 0.001 g. of sulfur. The use of solutions of any other strength, such as 0.1 *N*, involves more complicated calculation and is not advisable.

TENTATIVE METHOD OF TEST
FOR
NEUTRALIZATION NUMBER OF PETROLEUM PRODUCTS AND LUBRICANTS[1]

Serial Designation: D 188 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope. 1. The methods described herein are designed to indicate in petroleum products and lubricants and compounded products the presence of organic constitutents having acid characteristics and the contamination by alkalies and mineral acids.

Definitions. 2. (*a*) The Neutralization Number is the weight in milligrams of potassium hydroxide required to neutralize one gram of oil.

NOTE.—The Neutralization Number expresses the total amount of the mineral acid, and of the organic constituents having acid characteristics.

(*b*) The Alkali Neutralization Number is defined as the weight of acid required to neutralize one gram of oil, expressed in equivalent milligrams of potassium hydroxide.

(*c*) The Mineral Acid Neutralization Number is the number of milligrams of potassium hydroxide required to neutralize the mineral acid content in one gram of oil.

SOLUTIONS REQUIRED

3. (*a*) *Aqueous Potassium Hydroxide* (1 cc. = 5 mg. KOH).—Dissolve 5.1 g. of potassium hydroxide, c.p., in one liter of freshly boiled and cooled distilled water. Add a very small amount of barium hydroxide, sufficient to precipitate any potassium carbonate present. Standardize this solution against Bureau of Standards certified benzoic acid, using phenolphthalein as an indicator according to the relation:

$$\frac{5 \text{ mg. KOH}}{x \text{ mg. benzoic acid}} = \frac{56.104 \text{ g. KOH}}{122.048 \text{ g. benzoic acid}}$$

$$1 \text{ cc. of KOH} = 10.88 \text{ mg. benzoic acid.}$$

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

This weight of benzoic acid is required for standardization.

Make necessary adjustments so that the value of potassium hydroxide equals 5 mg. KOH per 1 cc.

NOTE.—Fit the solution bottle with a guard tube of soda lime to prevent access of carbon dioxide. The solution should be standardized at necessary intervals.

The weight of benzoic acid should be dissolved in 50 cc. of 95-per-cent alcohol and titrated cold. For blank, use same amount of alcohol and correct the titration.

(*b*) *Sulfuric Acid Solution* (1 cc. = 5 mg. KOH).—Match a sulfuric acid solution so that 1 cc. of the acid will be required to neutralize 1 cc. of the KOH, using phenolphthalein as an indicator, titrating in boiling solution.

(*c*) *Neutralized 95-per-cent Alcohol.*—Add a few drops of phenolphthalein and neutralize carefully the alcohol to a very faint pink end point with some of the above prepared alkali solution.

(*d*) *Phenolphthalein Indicator.*—Dissolve 10 g. of the indicator in 1 liter of 95-per-cent alcohol, preferably ethyl. Use 1 cc. of this strength for titration.

(*e*) *Methyl Orange Indicator.*—Dissolve 1 g. of the indicator in 1 liter of distilled water. Use 0.1 cc. of this strength for titration.

METHODS

4. *Method A.—Neutralization Number of Petroleum Products.*

Weight of Oil: Approximately 20 g. weighed accurately.

Volume of Solvent: 100 cc. of a mixture of 1:1 neutralized alcohol and distilled water.

Procedure: Agitate oil and solvent thoroughly and heat to boiling. Add 1 cc. of phenolphthalein indicator and titrate rapidly, with vigorous agitation, to a sharp pink end point. The titration must be completed in a hot solution, reheating same if found necessary.

The color change is noted in the alcohol water layer.

Calculation:

$$\frac{\text{(Cubic centimeters of KOH)} \times 5}{\text{Weight of oil taken}} = \text{mg. KOH per 1 g. of oil.}$$

5. *Method B.—Neutralization Number of Compounded Petroleum Products.*

Weight of Oil: Approximately 10 g. weighed accurately.

Volume of Solvent: 50 cc. of neutralized alcohol.

Procedure: Agitate oil and solvent thoroughly and heat to boiling. Add 1 cc. of phenolphthalein indicator and titrate rapidly, with vigorous agitation, to a sharp pink end point. The titration must be completed in a hot solution, reheating same if found necessary.

The color change is noted in the alcohol layer.

6. *Method C.*[1]*—Alkali or Mineral Acid Neutralization Number in Non-Compounded and Compounded Petroleum Products.*

Weight of Oil: 25 to 50 g. weighed accurately.

Volume of Solvent: Boiling distilled water, 200 cc.

Procedure: Pour the oil and water in a 500-cc. separatory funnel. Shake vigorously and after oil and water have separated, drain water into a 500-cc. casserole. Add 100 cc. of boiling water to oil and agitate. Drain separated water to casserole. Repeat washing and to the accumulated 100 cc. of water add 1 drop of phenolphthalein. Boil. If solution turns pink add 1 cc. of the indicator and titrate with the sulfuric acid solution until extraction is colorless.

If the addition of 1 drop of phenolphthalein causes no change in color, add 0.1 cc. of methyl orange. If color changes to red or pink, titrate with the KOH solution until the red color is just discharged.

An equal volume of distilled water shall be titrated with the standard solution used, and the amount of alkali or acid required shall be subtracted from the titration for blank correction.

Calculation: If the acid solution was required to discharge the phenolphthalein end point, the alkali neutralization number equals:

$$\frac{(\text{Cubic centimeters of acid}) \times 5}{\text{Weight of oil}}$$

If the alkali solution was required to discharge the methyl orange end point, the mineral acid neutralization number equals:

$$\frac{(\text{Cubic centimeters of alkali}) \times 5}{\text{Weight of oil}}$$

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[1] When the oil is acid, the acidity shall not be reported as sulfuric or hydrochloric acid unless the presence of these acids shall have been confirmed by tests.

TENTATIVE METHOD OF TEST
FOR
THERMAL VALUE OF FUEL OIL[1]

Serial Designation: D 240 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

I. APPARATUS

Combustion Bombs.

1. The Atwater, Davis, Emerson, Mahler, Parr, Peters, Williams or similar bombs may be used. The bomb shall have an inner surface of platinum, gold, porcelain enamel or other material which is not attacked by nitric and sulfuric acids, or other products of combustion.

Calorimeter Jacket.

2. The calorimeter shall be provided with a water jacket having a cover to protect the calorimeter from air currents. The jacket shall be kept filled with water within 2 or 3° C. of the temperature of the room (except in calorimeters which are totally submerged, where the jacket temperature is controlled by a thermostat) and should be stirred continuously by some mechanical stirring device.

Stirring of the Calorimeter Water.

3. The water in the calorimeter shall be stirred sufficiently well to give consistent thermometer readings while the temperature is rising rapidly. The speed of stirring should be kept constant. A motor-driven screw or turbine stirrer is recommended and the speed should not be excessive. This may be determined by adjusting the temperature of the calorimeter to equality with that of the jacket and allowing the stirrer to run continuously for 10 minutes. If the temperature of the calorimeter rises more than about 0.01° C. in this length of time, the rate of stirring is excessive. Accurate results cannot be obtained when too much energy is supplied by the stirring device or when the rate of stirring is irregular. The portion of the stirring device immersed in the calorimeter should be separated from that outside by non-conducting material, such as hard rubber, to prevent conduction of heat from the motor or outside air.

Thermometers.

4. The thermometers used shall have been certified by a government testing bureau and shall be used with the corrections given on

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. R. P. Anderson, Secretary of Committee D-2 on Petroleum Products and Lubricants, 250 Park Ave., New York City.

the certificate. This shall also apply to electrical resistance or thermoelectric thermometers. Correction shall also be made for the temperature of the emergent stem of all mercurial thermometers, and for the "setting" of Beckmann thermometers. For accurate work, either Beckmann or special calorimetric thermometers, graduated to 0.01 or 0.02° C., are required. Such thermometers should be tapped lightly just before each reading to avoid errors caused by the sticking of the mercury meniscus, particularly when the temperature is falling. A convenient method is to mount a small electric buzzer directly on the top of the thermometer and connect it with a dry cell and a push button. The button should be pressed for a few seconds immediately before each reading.

Oxygen.

5. The oxygen used for combustions shall be free from combustible material. The bomb when filled should contain at least 5 per cent of nitrogen to insure complete oxidation of the sulfur. The total amount of oxygen contained in the bomb for combustion shall be not less than 5 g. per gram of fuel oil. But the combustion must be complete, as shown by the absence of any sooty deposit on opening the bomb after firing.

Firing Wire.

6. The fuel oil in the bomb may be ignited by means of either iron or platinum wire. If iron wire is used, it should be of about No. 34 B. & S. gage and not more than 10 cm. (preferably 5 cm.) should be used at a time. A correction of 1600 calories per gram weight of iron wire burned shall be subtracted from the observed number of calories.

Standardization.

7. The water equivalent of a calorimeter can best be determined by the use of the standard combustion samples supplied by the U. S. Bureau of Standards. The required water equivalent is equal to the weight of the sample multiplied by its heat of combustion per gram and divided by the corrected rise in temperature.

The calorimeter shall be standardized by the combustion of standard samples supplied by the Bureau of Standards, and used according to the directions given in the certificates which accompany them. A standardization shall consist of a series of not less than five combustions of each of two of the standard materials which are, sucrose, naphthalene and benzoic acid. The conditions as to the amount of water, oxygen, firing wire, method of correcting for radiation, etc., under which these combustions are made, shall be the same as for fuel oil combustions. In the case of any disagreement between contracting parties a check standardization may consist of two or more combustions of standardizing samples.

II. PROCEDURE

Preparation of Sample.

8. Approximately enough oil shall be taken to give a thermometer rise of from 3 to 4° C. After weighing, the sample should preferably be immediately placed in the bomb and this closed. This procedure is necessary to avoid sublimation in the use of naphthalene for standardization.

Preparation of the Bomb.

9. The firing wire, if iron, shall be measured and coiled in a small spiral and connected between the platinum terminals, using, if necessary, a piece of platinum wire somewhat heavier than the iron wire to make the connection. The platinum and the iron shall both be clean. About 0.5 cc. of water should be placed in the bottom of the bomb to saturate with moisture the oxygen used for combustion. When the crucible is put in place in the bomb, the firing wire should touch the fuel oil or briquet of standard material. For the combustion of standardizing samples, iron wire is preferable to platinum.

Filling the Bomb with Oxygen.

10. Oxygen from the supply tank shall be admitted slowly, to avoid blowing the oil from the crucible, until a pressure is reached as indicated by the following table:

CAPACITY OF BOMB, CC.	MINIMUM GAGE PRESSURE, ATMOSPHERES
300 to 350	40
350 to 400	35
400 to 450	30
450 to 500	27.5
Above 500	25

Calorimeter Water.

11. The calorimeter shall be filled with the required amount of distilled water, depending upon the type of calorimeter. The amount may be determined either by measurement in a standardized flask or by weighing. The amount shall be kept the same as that used in the standardization of the apparatus.

Temperature Adjustments.

12. The initial temperature in the calorimeter shall be so adjusted that the final temperature, after the combustion, will not be more than 1° C., preferably about 0.5° C., above that of the jacket. Under these conditions, the total correction for heat gained from or lost to the surroundings will be small when the rise of temperature is 3 or 4° C. and the effect of evaporation will also be small.

Firing Current.

13. The electric current used for firing the charge shall be obtained from storage or dry cells having an electromotive force of not more than 12 volts. A higher voltage is liable to cause an arc between the firing terminals, introducing additional heat which cannot be measured with certainty. The circuit should be closed by means of a switch which should remain closed for not more than 2 seconds. When

possible, it is recommended that an ammeter be used in the firing circuit to indicate when the firing wire has burned out.

Method of Making an Observation.

14. The bomb, when ready for firing, shall be placed in the calorimeter, the firing wires connected, the cover put in place and the stirrer and thermometer so placed as not to be in contact with the bomb or container. The stirrer shall then be started and after the thermometer reading has become steady, not less than 2 minutes after the stirrer is started, the temperatures shall be read at 1-minute intervals for 5 minutes and the charge then fired, the exact time of firing being noted. Observations of temperature shall then be made at intervals depending upon the method to be used for computing the cooling correction. When the temperature has reached its maximum and is falling uniformly, a series of thermometer readings shall be taken at 1-minute intervals for 5 minutes to determine the final cooling rate.

Titration.

15. After a combustion and after allowing the gas to escape, the bomb shall be opened and the inside examined for traces of unburned material or sooty deposit. If these are found, the observations shall be discarded. If the combustion appears complete, the bomb shall be rinsed out thoroughly and the washings titrated with a standard alkali solution (1 cc. = 0.02173 g. HNO_3 = 5 calories) using methyl-orange or methyl-red indicator to determine the amount of acid formed. A correction of 230 calories per gram of HNO_3 should be subtracted from the total heat observed. An additional correction of 1300 calories per gram of sulfur in the oil should be made for the excess of difference in heats of formation of SO_2 and aqueous H_2SO_4 over the heat of formation of aqueous HNO_3.

III. COMPUTATION OF RESULTS

Computation of Results.

16. The following method of computation is recommended to take the place of the Pfaundler or other similar formulas for computing the cooling correction (radiation correction):

Observe (1) the rate of rise, r_1, of the calorimeter temperature in degrees per minute for 5 minutes before firing; (2) the time, a, at which the last temperature reading is made immediately before firing; (3) the time, b, when the rise of temperature has reached six-tenths of its total amount (this point can generally be determined by adding to the temperature observed before firing, 60 per cent of the expected temperature rise, and noting the time at which this point is reached); (4) the time, c, of a thermometer reading taken when the temperature change has become uniform some 5 minutes after firing; (5) the final rate of cooling, r_2, in degrees per minute for 5 minutes.

Multiply the rate r_1 by the time $b - a$ in minutes and tenths of a minute, and add to this product (subtracted if the temperature was falling at the time a) to the thermometer reading taken at the time a. Multiply the rate r_2 by the time $c - b$ and add this product (subtracted if the temperature was rising at the time c and later) to the thermometer reading taken at the time c. The difference of the two thermometer readings thus corrected, provided the corrections from the certificate have already been applied, gives the total rise of temperature due to the combustion. This, multiplied by the water equivalent of the calorimeter, gives the total amount of heat liberated. Divide this result, corrected for the heats of formation of HNO_3 and H_2SO_4 observed and for the heat of combustion of the firing wire, when that is included, by the weight of the charge to find the heat of combustion in calories per gram. Calories per gram multiplied by 1.8 give the British thermal units per pound.

17. The permissible differences in duplicate determinations are as follows:

Same analyst	0.3 per cent
Different analysts	0.5 per cent

18. In practice, the time $b - a$ will be found so nearly constant for a given calorimeter with the usual amounts of fuel that b need be determined only occasionally.

The results shall be reduced to calories per gram or British thermal units per pound of oil.

TENTATIVE SPECIFICATIONS[1]

FOR

ASPHALT CEMENT, 40 TO 50 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC-CONCRETE PAVEMENTS AND AS FILLER FOR BRICK AND BLOCK PAVEMENTS[2]

Serial Designation: D 99 – 26 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1923, 1926.

Properties. 1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec. . . . . . . 40 to 50

(*b*) Flash point (open cup) . . . . not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr. . . . . not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating . . not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.) . . . . not less than 30 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride . . . . not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] As a filler, the asphalt cement is not to be used in admixtures with sand.

[3] A.S.T.M. Standards Adopted in 1925.

(*b*) *Flash Point:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92);[1]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[1]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 26 T);[2]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 26 T).[3]

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[1] 1924 Book of A.S.T.M. Standards. [2] See p. 886. [3] See p. 879.

TENTATIVE SPECIFICATIONS[1]
FOR
ASPHALT CEMENT, 50 TO 60 PENETRATION, FOR USE IN SHEET ASPHALT AND ASPHALTIC-CONCRETE PAVEMENTS AND AS FILLER FOR BLOCK PAVEMENTS[2]

Serial Designation: D 100 – 26 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1921; Revised, 1922, 1923, 1926.

Properties. 1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec......50 to 60

(*b*) Flash point (open cup)........not less than 175° C. (347° F.)

(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr...not more than 2 per cent

Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..not less than 60 per cent

(*d*) Ductility at 25° C. (77° F.)............not less than 30 cm.

(*e*) Proportion of bitumen soluble in carbon tetrachloride...................................not less than 99 per cent

Note.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing. 2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[3]

(*b*) *Flash Point:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92);[4]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] For use as filler for block pavements, the asphalt should be mixed with a suitable proportion of sand.

[3] A.S.T.M. Standards Adopted in 1925.

[4] 1924 Book of A.S.T.M. Standards.

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[1]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 26 T);[2]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 26 T).[3]

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[1] 1924 Book of A.S.T.M. Standards. [2] See p. 886. [3] See p. 879.

TENTATIVE SPECIFICATIONS[1]

FOR

ASPHALT CEMENT, 60 TO 70 PENETRATION, FOR USE IN SHEET ASPHALT, ASPHALTIC CONCRETE, AND ASPHALT-MACADAM PAVEMENTS AND AS FILLER FOR BLOCK PAVEMENTS[2]

Serial Designation: D 101 – 26 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1923, 1926.

Properties.

1. The asphalt cement shall be homogeneous and free from water. It shall conform to the following requirements:

(*a*) Penetration at 25° C. (77° F.), 100 g., 5 sec.......60 to 70
(*b*) Flash point (open cup)........not less than 175° C. (347° F.)
(*c*) Loss on heating at 163° C. (325° F.), 50 g., 5 hr.............. ....not more than 2 per cent
Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt cement before heating..not less than 60 per cent
(*d*) Ductility at 25° C. (77° F.)............not less than 30 cm.
(*e*) Proportion of bitumen soluble in carbon tetrachloride....... ....not less than 99 per cent

NOTE.—When less than 99 per cent of the asphalt cement is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] For use as filler for block pavements, the asphalt should be mixed with a suitable proportion of sand.

[3] A.S.T.M. Standards Adopted in 1925.

(*b*) *Flash Point:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92);[1]

(*c*) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[1]

(*d*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 26 T);[2]

(*e*) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 – 26 T).[3]

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[1] 1924 Book of A.S.T.M. Standards. [2] See p. 846. [3] See p. 879.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT FILLER FOR BRICK PAVEMENTS (BLOWN TYPE)[1]

Serial Designation: D 241 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

Properties. 1. The asphalt filler shall be homogeneous and free from water, and shall not foam when heated to 200° C. (392° F.). It shall conform to the following requirements:

- (*a*) Flash Point (open cup)..not less than 200° C. (392° F.)
- (*b*) Softening Point (ring and ball method)....65° C. (149° F.) to 110° C. (230° F.)
- (*c*) Penetration at 0° C. (32° F.), 200 g., 1 min..............................not less than 10
  Penetration at 25° C. (77° F.), 100 g., 5 sec....30 to 50
  Penetration at 46.1° C. (115° F.), 50 g., 5 sec..........................not more than 110
- (*d*) Loss on Heating at 163° C. (325° F.), 50 g., 5 hr.....................less than 1.0 per cent
  Penetration at 25° C. (77° F.), 100 g., 5 sec., of residue after heating at 163° C. (325° F.) as compared with penetration of asphalt filler before heating...................................not less than 60 per cent
- (*e*) Ductility at 25° C. (77° F.)........not less than 3 cm.
- (*f*) Proportion of Bitumen Soluble in Carbon Tetrachloride.......not less than 99 per cent

Note.—When less than 99 per cent of the asphalt filler is soluble in carbon tetrachloride, the percentage of bitumen (solubility in carbon disulfide) shall be reported.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington, Ave., New York City.

Methods of Testing.

2. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(a) *Flash Point:* Standard Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92);[1]

(b) *Softening Point:* Standard Method of Test for Softening Point of Bituminous Materials (Ring-and-Ball Method) (Serial Designation: D 36);[2]

(c) *Penetration:* Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5);[3]

(d) *Loss on Heating:* Standard Method of Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6);[1]

(e) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 - 26 T);[4]

(f) *Proportion of Bitumen Soluble in Carbon Tetrachloride:* Tentative Method of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride (Serial Designation: D 165 - 26 T).[5]

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[1] 1924 Book of A. S. T M. Standards.

[2] A.S.T.M. Standards Adopted in 1926.

[3] A.S.T.M. Standards Adopted in 1925.

[4] See p. 886.

[5] See p. 879.

TENTATIVE SPECIFICATIONS
FOR
MINERAL FILLER FOR SHEET ASPHALT AND BITUMINOUS CONCRETE PAVEMENTS[1]

Serial Designation: D 242 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Composition.

1. The mineral filler shall consist of limestone dust, portland cement, or other mineral matter from sources agreed upon between the purchaser and seller.

Physical Properties.

2. The material shall be thoroughly dry and free from lumps consisting of aggregations of fine particles. It shall meet the following requirements for mechanical analysis:

Passing 200-mesh sieve	not less than 65 per cent
Total passing 80-mesh sieve	not less than 95 per cent
Total passing 30-mesh sieve	100 per cent

Method of Testing.

3. The mechanical analysis shall be determined in accordance with the Standard Method of Mechanical Analysis of Sand or Other Fine Highway Material, Except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7), of the American Society for Testing Materials,[2] using only the 30, 80 and 200-mesh sieves.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] 1924 Book of A.S.T.M. Standards.

TENTATIVE METHOD OF TEST

FOR

SPECIFIC GRAVITY OF ROAD OILS, ROAD TARS, ASPHALT CEMENTS AND SOFT TAR PITCHES[1]

Serial Designation: D 70 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1920; Revised, 1926.

Definition. 1. The specific gravity of road oils, road tars, asphalt cements and soft tar pitches shall be expressed as the ratio of the weight of a given volume of the material at 25° C. (77° F.) to that of an equal volume of water at the same temperature and shall be expressed thus:

Specific Gravity 25° C. (77° F.).

Apparatus. 2. The determination of specific gravity shall be made with a pyknometer or weighing bottle (Fig. 1), which shall consist of a straight-walled glass tube approximately 70 mm. long and 22 mm. in diameter, carefully ground to receive an accurately fitting solid glass stopper with a hole of 1.5 to 1.7-mm. bore in place of the usual capillary opening. The lower part of the stopper is made concave in order to allow all air bubbles to escape through the bore. The depth of the cup-shape depression shall be about 4.8 mm. at the center. The stoppered tube should have a capacity of about 24 cc. and when empty should weigh not over 35 g.

Procedure. 3. Before making a determination, the pyknometer with stopper shall first be calibrated by weighing it clean and dry upon an analytical balance. This weight is called "*a.*" It shall then be filled with freshly boiled distilled water at a temperature of 25° C. (77° F.), the stopper firmly inserted, all surplus moisture wiped from the surface with a clean dry cloth and again weighed. This weight is called "*b*."

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

4. When determining the specific gravity of road oils or road tars which flow readily, the material shall be brought to a temperature of 25° C. (77° F.) and poured into the pyknometer until it is full, with care to prevent the inclusion of air bubbles. The stopper is then firmly inserted and all excess of material forced through the opening is carefully removed with a clean dry cloth. The pyknometer and contents are then weighed and this weight is called "*c*." The specific gravity of the material shall be calculated from the formula:

$$\text{Specific Gravity} = \frac{c-a}{b-a}$$

FIG. 1.—Pyknometer or Weighing Bottle.

5. When determining the specific gravity of tar and asphalt products which are too viscous for the method described in Section 4, a small amount of the material shall be brought to a fluid condition by the gentle application of heat, care being exercised to prevent loss by evaporation. When sufficiently fluid, enough is poured into the clean dry pyknometer to about half fill it. Precautions shall be taken to keep the material from touching the sides of the tube above the final level and to prevent the inclusion of air bubbles. The tube should be slightly warmed before filling. The pyknometer and contents are then cooled to room temperature and weighed with the stopper. This weight is called "*c*." The pyknometer is next removed from the balance, filled with freshly boiled distilled water, and the stopper firmly inserted. It is then completely immersed for not less than 30 minutes in a beaker of distilled water maintained at 25° C. (77° F.) after which it is removed, and all surplus water is wiped off with a clean cloth. It is immediately weighed. This weight is called "*d*." The specific gravity of the material shall be calculated from the formula:

$$\text{Specific Gravity} = \frac{c-a}{(b-a)-(d-c)}$$

Precautions.

6. When making the specific gravity determination it is important that:

(*a*) Only freshly boiled distilled water shall be used.

(*b*) When weighing the pyknometer completely filled, the temperature of its contents shall be within 1° C. (1.8° F.) of 25° C. (77° F.).

(*c*) Precautions shall be taken to prevent expansion and overflow of the contents from the heat of the hand when wiping the surface of the pyknometer.

(*d*) The presence of all air bubbles shall be eliminated in filling the pyknometer and inserting the stopper.

(*e*) Weighings shall be made quickly after filling the pyknometer and shall be accurate to 1 mg. A number of trial fillings and catch weights may be necessary to obtain the desired degree of accuracy.

(*f*) To prevent breakage of the pyknometer when cleaning it out after a determination has been made upon a very viscous or semi-solid material, it will be found advisable to warm it in an oven at not over 100° C. until most of the material may be poured out and then to swab it with a piece of soft cloth or cotton waste. When cool it may be finally rinsed with carbon disulfide, benzol or other solvent and wiped clean.

Accuracy.

7. The limit of accuracy of the test is ±0.005 specific gravity.

TENTATIVE METHOD OF TEST
FOR
SPECIFIC GRAVITY OF ASPHALTS AND TAR PITCHES SUFFICIENTLY SOLID TO BE HANDLED IN FRAGMENTS.[1]

Serial Designation: D 71 – 26 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1920; Revised, 1926.

Definition. 1. The specific gravity of asphalts and tar pitches shall be expressed as the ratio of the weight of a given volume of the material at 25° C. (77° F.) to that of an equal volume of water at the same temperature and shall be expressed thus:

Specific Gravity 25° C. (77° F.).

Apparatus. 2. The determination of specific gravity shall be made with an analytical balance equipped with a pan straddle or other stationary support (Fig. 1).

Test Specimen. 3. The test specimen shall be a cube of the material measuring approximately $\frac{1}{2}$ in. to the edge. It shall be prepared by melting a small sample of the material by the gentle application of heat, care being exercised to prevent loss by evaporation, and pouring when sufficiently fluid into a $\frac{1}{2}$-in. brass cubical mold, which has been amalgamated with mercury and which is placed on an amalgamated brass plate. Precautions should be taken to prevent the inclusion of air bubbles. The hot material should slightly more than fill the mold and when cool the excess may be cut off with a hot spatula. The specimen shall be removed from the mold when cooled to room temperature.

Procedure. 4. The balance shall first be tared with a piece of fine waxed silk thread sufficiently long to reach from the hook on one of the pan supports to the straddle or rest. The test specimen shall then be attached to the thread, so as to be suspended about 1 in. above the straddle from the hook on the pan support, and weighed. This weight is called "*a*" and shall be accurate to 0.1 mg. The specimen, still suspended by the thread, shall then be weighed completely immersed in freshly boiled distilled water at 25° C. (77° F.) ±1° C. (1.8° F.), adhering air bubbles being first removed with a fine wire. This weight is called "*b*" and shall also be accurate to 0.1 mg.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

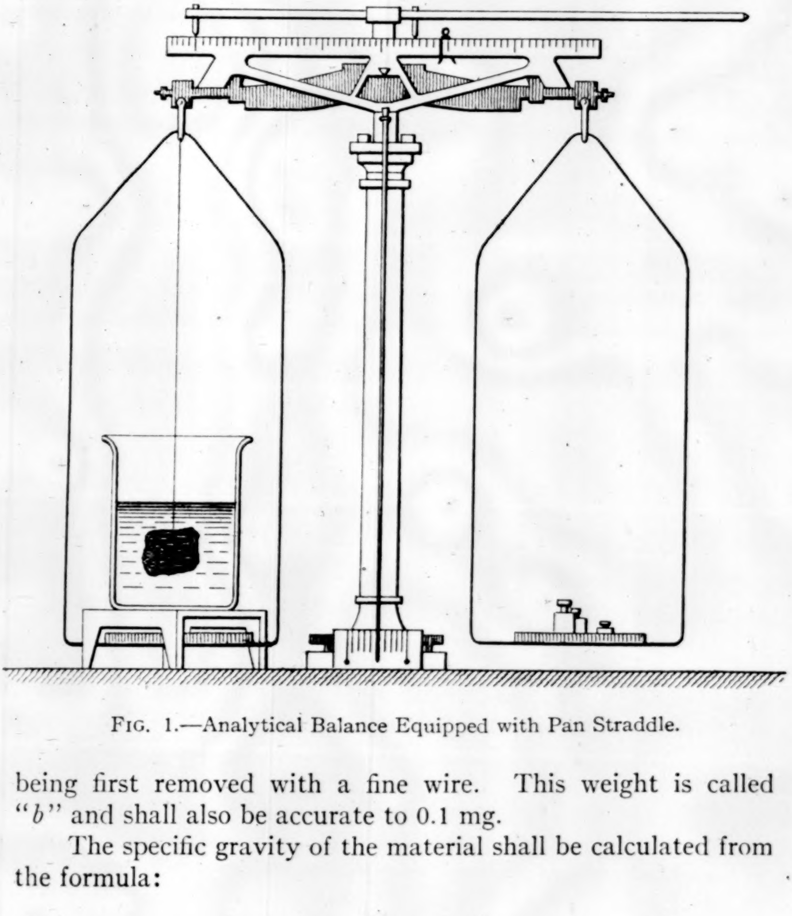

FIG. 1.—Analytical Balance Equipped with Pan Straddle.

The specific gravity of the material shall be calculated from the formula:

$$\text{Specific Gravity} = \frac{a}{a-b}$$

Accuracy. 5. The limit of accuracy of the test is ±0.005 specific gravity.

TENTATIVE METHOD OF TEST
FOR
CONSISTENCY OF PORTLAND-CEMENT CONCRETE[1]

Serial Designation: D 138 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1922; REVISED, 1925, 1926.

Scope. 1. This test covers the method to be used both in the laboratory and in the field for determining consistency of concrete[2].

Apparatus. 2. The test specimen shall be formed in a mold of No. 16 gage galvanized metal in the form of the lateral surface of the frustrum of a cone with the base 8 in. in diameter, the upper surface 4 in. in diameter, and the altitude 12 in. The base and the top shall be open and parallel to each other and at right angles to the axis of the cone. The mold shall be provided with foot pieces and handles as shown in Fig. 1.

Sample. 3. When the test is made at the mixer, the sample shall be taken from the pile of concrete immediately after the entire batch has been discharged. When testing concrete that has been hauled from a central mixing plant, the sample shall be taken from the concrete immediately after it has been dumped on the subgrade.

Procedure. 4. The mold shall be placed on a flat, non-absorbent surface, such as a smooth plank or a slab of concrete, and the operator shall hold the form firmly in place, while it is being filled, by standing on the foot pieces. The mold shall be filled to about one-fourth of its height with the concrete which shall then be puddled, using 25 strokes of a $\frac{5}{8}$-in. rod, 2 ft. long, bullet pointed at the lower end. The filling shall be completed in successive layers similar to the first and the top struck off so that the mold is exactly filled. The mold shall then be removed by being raised vertically, immediately after being filled. The molded concrete shall then be allowed to subside until quiescent and the height of the specimen measured.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] This test is not considered applicable when there is a considerable amount of coarse aggregate over 2 in. in size in the concrete. The committee is now working on a method suitable for determining the consistency of concrete using aggregate over 2 in. in size.

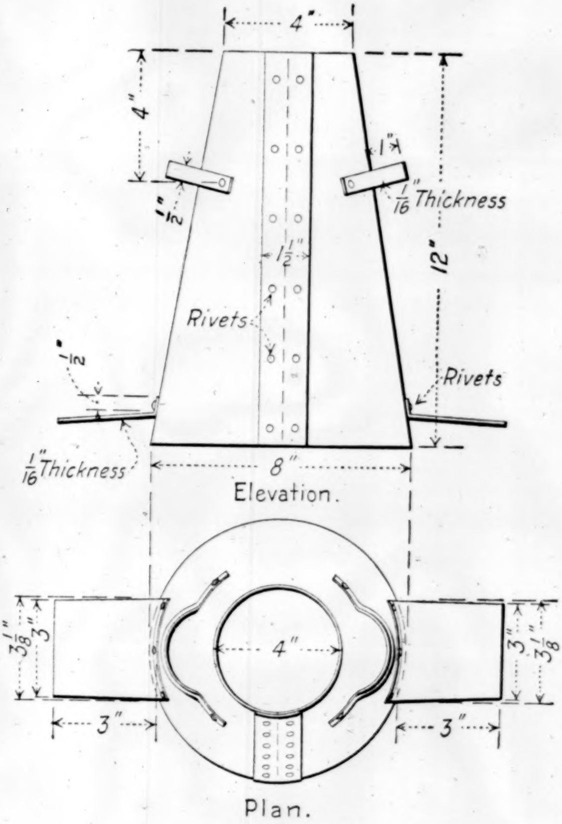

FIG. 1.

Slump.

5. The consistency shall be recorded in terms of inches of subsidence of the specimen during the test, which shall be known as the slump.

$$\text{Slump} = 12 - \text{inches of height after subsidence}$$

TENTATIVE METHOD OF TEST
FOR
THE DETERMINATION OF BITUMEN[1]

Serial Designation: D 4 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1923; REVISED, 1926.

Scope. 1. Bitumen may usually be expeditiously and accurately determined by Method No. 1, Section 5. In the case of certain native asphalts containing finely divided mineral matter, the mineral residue is not easily retained by the filter and it is necessary to resort to Method No. 2, Section 6, in order to obtain accurate results. Method No. 2 shall not be used unless the filter clogs unduly or unless the mineral matter passing through the filter exceeds 0.5 per cent. In every case the report shall indicate whether Method No. 1 or Method No. 2 has been employed.

I. APPARATUS

Apparatus. 2. The apparatus shall consist of the following:

(*a*) Gooch crucible, approximately 4.4 cm. in width at the top, tapering to 3.6 cm. at the bottom, with a depth of 2.5 cm.;

(*b*) Filtering flask;

(*c*) Rubber stopper;

(*d*) Filter tube;

(*e*) Section of rubber tubing to hold the Gooch crucible on the filter tube;

(*f*) Asbestos (amphibole) cut in pieces not exceeding 1 cm. in length, shredded and shaken up with water;

(*g*) Two 150-cc. Erlenmeyer flasks;

(*h*) Bunsen burner;

(*i*) Drying oven;

(*j*) Suction pump;

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

This method is in effect a revision of the Standard Method of Test for Soluble Bitumen. The Standard Method, which was last published under the Serial Designation: D 4 - 11, has accordingly been withdrawn.

(*k*) Rubber tubing;
(*l*) Analytical balance;
(*m*) Desiccator.

II. PREPARATION OF SAMPLE

3. The sample shall be representative and if it contains more than 2 per cent of water it shall be dehydrated by distillation in a copper still in accordance with the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20) of the American Society for Testing Materials,[1] the water-free distillate being returned to the residue. If the material is hard and brittle, it may be ground and dried at a temperature below the temperature of volatilization of the material.

III. PROCEDURE

Preparation of Gooch Crucible.

4. The Gooch crucible shall be set in the filter tube inserted in the stopper of the filtering flask. The flask shall be connected with the suction pump. Before suction shall be applied, the crucible shall be filled with asbestos suspended in water which shall be allowed to partly settle in the crucible. A light suction shall be applied to draw off the water, leaving a firm mat of asbestos in the crucible. More suspended asbestos shall be added and the process repeated until a felt is built up that barely transmits light. The felt shall then be thoroughly washed with water, dried in a drying oven, and ignited over a Bunsen burner. The crucible shall then be cooled in a desiccator and weighed.

(*a*) *Method No. 1*

Procedure No. 1.

5. An amount of material which shall contain approximately one gram of bitumen shall be weighed into a tared Erlenmeyer flask. One hundred cubic centimeters of chemically pure carbon disulfide shall be added to the flask in small portions with continued agitation until all lumps disappear and nothing adheres to the bottom. The flask shall be corked and set aside for fifteen minutes.

The Gooch crucible shall be set up again with the suction flask and the carbon disulfide solution carefully decanted through the asbestos felt, with or without light suction as may be found necessary. No sediment shall be allowed to go onto the filter. A small amount of carbon disulfide shall be used to wash down the sides of the flask and then the precipitate shall be brought onto the felt and the flask scrubbed with a feather if necessary to remove all precipitate. The contents of the crucible shall be washed with carbon disulfide until the washings are colorless. Suction shall be applied to the crucible to remove the carbon disulfide. The crucible shall be dried in the oven at 100 to 125° C. for twenty minutes, cooled in the desiccator and weighed.

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[1] 1924 Book of A.S.T.M. Standards.

In case insoluble matter adheres to the flask, the flask shall be dried and weighed and the increase in weight over the original weight shall be added to the weight of insoluble matter in the crucible.

The crucible shall be ignited at a red heat and after thorough ignition, cooled and weighed.

The weight of substance taken, minus the total weight of matter insoluble in carbon disulfide, is the total bitumen. The weight of material after ignition is ash.

(*b*) *Method No. 2*

Procedure No. 2.

6. Material shall be weighed out in the same way as in (*a*) Method No. 1 (Section 5) into a tared Erlenmeyer flask, and treated with 100 cc. of chemically pure carbon disulfide.

The flask shall be loosely corked and shaken at intervals until all large particles of material have been broken down. The flask shall be left undisturbed for 48 hours. The solution shall be decanted into a similar tared flask, care being taken to disturb as little of the residue as possible. The first flask shall be treated again with fresh carbon disulfide as before and left undisturbed for 48 hours. The solution from the second flask shall then be carefully decanted upon the Gooch crucible without use of vacuum, and this shall be followed by the solution from the first flask. The filter shall be washed with fresh carbon disulfide. The residue remaining in each flask shall be shaken again with fresh carbon disulfide and allowed to settle for 24 hours. The solution from both flasks shall then be decanted through the filter and the residues remaining in the flasks shall be washed again with carbon disulfide, the solution decanted and the process repeated until the washings are practically colorless. The temperature shall be maintained between 20 and 25° C.

The crucible and both flasks shall be dried at 100 to 125° C. and weighed. The filtrate containing the bitumen shall be evaporated, the bituminous residue burned, and the weight of the ash thus obtained added to that of the residue in the two flasks and the crucible. The sum of these weights deducted from the weight of substance taken is the weight of bitumen.

TENTATIVE METHOD OF TEST
FOR
THE DETERMINATION OF PROPORTION OF BITUMEN SOLUBLE IN CARBON TETRACHLORIDE[1]

Serial Designation: D 165 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1923; REVISED, 1926.

I. APPARATUS

Apparatus.

1. The apparatus shall consist of the following:

(*a*) Gooch Crucible, approximately 4.4 cm. in width at the top, tapering to 3.6 cm. at the bottom, with a depth of 2.5 cm.

(*b*) Filtering flask;

(*c*) Rubber stopper;

(*d*) Filter tube;

(*e*) Section of rubber tubing to hold the Gooch crucible on the filter tube;

(*f*) Asbestos (amphibole) cut in pieces not exceeding 1 cm. in length, shredded and shaken up with water;

(*g*) Two 150-cc. Erlenmeyer flasks;

(*h*) Bunsen burner;

(*i*) Drying oven;

(*j*) Suction pump;

(*k*) Rubber tubing;

(*l*) Analytical balance;

(*m*) Desiccator.

II. PREPARATION OF SAMPLE

2. The sample shall be representative and if it contains more than 2 per cent of water it shall be dehydrated by distillation in a copper still in accordance with the Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20) of the American Society for Testing Materials,[2] and water-

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] 1924 Book of A.S.T.M. Standards.

free distillate returned to the residue. If the material is hard and brittle, it may be ground and dried at a temperature below the temperature of volatilization of the material.

III. PROCEDURE

Preparation of Gooch Crucible.

3. The Gooch crucible shall be set in the filter tube inserted in the stopper of the filtering flask. The flask shall be connected with the suction pump. Before suction is applied, the crucible shall be filled with asbestos suspended in water which shall be allowed to partly settle in the crucible. A light suction shall be applied to draw off the water, leaving a firm mat of asbestos in the crucible. More suspended asbestos shall be added and the process repeated until a felt is built up that barely transmits light. The felt shall then be thoroughly washed with water, dried in a drying oven, and ignited over a Bunsen burner. The crucible then shall be cooled in a desiccator and weighed.

Procedure.

4. An amount of material which shall contain approximately one gram of bitumen shall be weighed into a tared Erlenmeyer flask. One hundred cubic centimeters of chemically pure carbon tetrachloride shall be added to the flask in small portions with continued agitation until all lumps disappear and nothing adheres to the bottom. The flask shall be corked and set aside in subdued light for at least 12 hours.

The Gooch crucible shall be set up again with the suction flask and the carbon tetrachloride solution carefully decanted through the asbestos felt, with or without light suction as may be found necessary. No sediment shall be allowed to go onto the filter. A small amount of carbon tetrachloride shall be used to wash down the sides of the flask and then the precipitate shall be brought onto the felt and the flask scrubbed with a feather if necessary to remove all precipitate. The contents of the crucible shall be washed with carbon tetrachloride until the washings are colorless. Suction shall be applied to the crucible to remove the carbon tetrachloride. The crucible shall be dried in the oven at 100 to 125° C. for twenty minutes, cooled in the desiccator, and weighed.

In case insoluble matter adheres to the flask, the flask shall be dried and weighed and the increase in weight over the original weight shall be added to the weight of insoluble matter in the crucible.

The proportion of bitumen soluble in carbon tetrachloride shall be reported on the basis of total bitumen taken as 100.

$$\text{Proportion of Bitumen Soluble in Carbon Tetrachloride.} = \frac{\text{Bitumen Soluble in Carbon Tetrachloride}}{\text{Total Bitumen}}$$

TENTATIVE METHOD OF TEST
FOR
DISTILLATION OF BITUMINOUS MATERIALS SUITABLE FOR ROAD TREATMENT[1]

Serial Designation: D 20 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

This method is presented without any definition of its scope and accuracy since it is believed that it will become applicable, during the coming year, to a wider range of materials than indicated by the title. So far the committee has determined its accuracy on one class of materials and further work will be done.

I. APPARATUS

Apparatus. 1. The apparatus consists of a flask, condenser tube, shield, receivers and thermometers as specified in Sections 2 to 6.

Flask. 2. *Flask.*—The distillation flask, Fig. 1, shall be a side neck distilling flask, having the following dimensions:

Diameter of bulb, outside	86 mm.	± 1.5 mm.
Diameter of neck, inside	22 mm.	± 1.0 mm.
Diameter of tubulature, inside	10.0 mm.	± 0.5 mm.
Length of neck	43 mm.	± 1.0 mm.
Distance, top of neck to tubulature	25 mm.	± 1.0 mm.
Length of tubulature	220 mm.	± 5.0 mm.
Angle of tubulature	73 deg.	± 1. deg.

Condenser Tube. 3. *Condenser Tube.*—The condenser tube shall be a suitable form of tapered glass tubing of the following dimensions:

Outside diameter of small end	12.5 mm.	permissible variation	± 1.5 mm.
Outside diameter of large end	28.5 mm.	permissible variation	± 3.0 mm.
Length	360.0 mm.	permissible variation	± 4.0 mm.

Shield. 4. *Shield.*—An asbestos shield of the form and approximate dimensions shown in Fig. 2 shall be used to protect the retort from air currents and to prevent radiation. This may be covered with galvanized iron, as such an arrangement is more convenient and more permanent.

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[1] Criticisms of this Tentative Method are solicited, and should be directed to Mr. Prévost Hubbard. Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

Committee D-4 recommends that the method should not be made operative until January, 1927.

This Tentative Method, when adopted, will supersede the present Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20), 1924 Book of A.S.T.M. Standards.

Receiver.

5. *Receiver.*—The distillates will be collected in tared Erlenmeyer flasks having a capacity of 50 to 100 ml.

Thermometer.

6. *Thermometer.*—The thermometer shall conform to the following requirements. These specifications cover a total-immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the range being from 0 to 400° C. or 30 to 760° F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 0 to 400° C. in 1° C. or 30 to 760° F. in 2° F.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

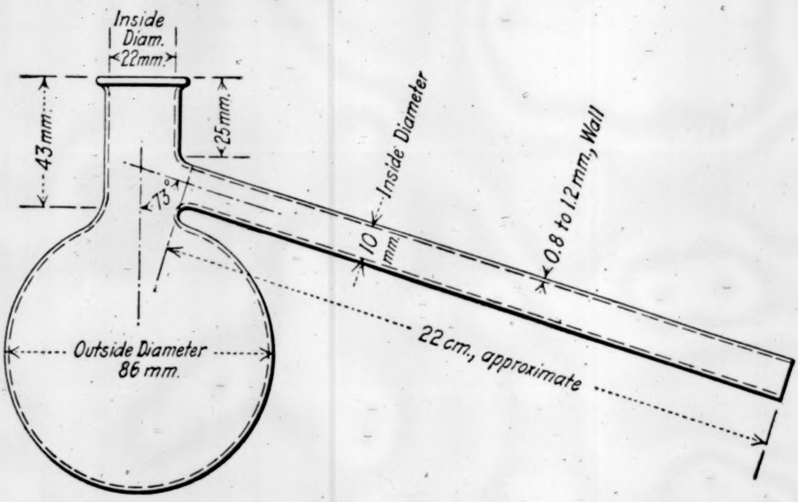

FIG. 1.—Distillation Flask.

BULB: Corning normal or equally suitable thermometric glass.
Length, 10 to 15 mm. (0.39 to 0.59 in.).
Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 25 to 35 mm. (0.98 to 1.38 in.).

DISTANCE TO 400° C. OR 752° F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION. Total.

SPECIAL MARKING: "A.S.T.M. High Distillation," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale up to 370° C. or 700° F. when the thermometer is standardized as provided below shall not exceed 1° C. or 2° F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50° C. or 100° F. up to 370° C. or 700 °F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature between 360 and 370° C. or 680 and 700° F. for 24 hours, the accuracy shall be within the limit specified.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High Distillation, 0 to 400° C." or "A.S.T.M. High Distillation, 30 to 760° F." according to the type of thermometer.

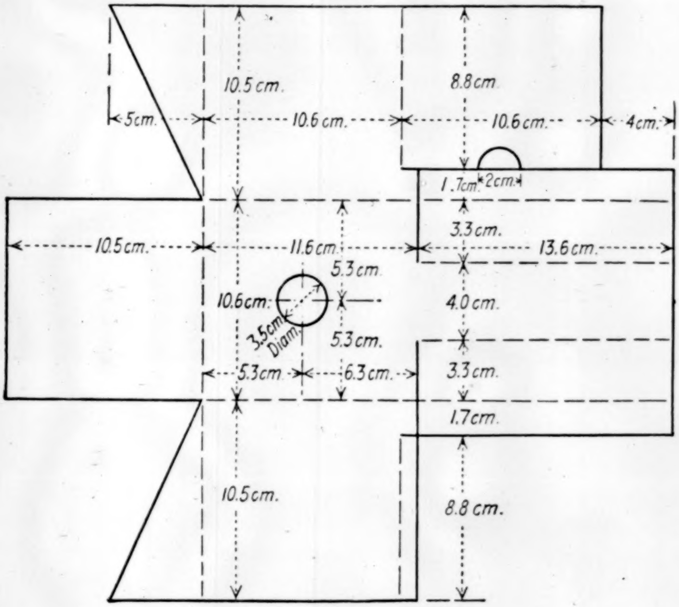

FIG. 2.—Asbestos Shield.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

II. PREPARATION OF SAMPLE

Sampling. 7. The sample, as received, shall be thoroughly stirred and agitated, warming, if necessary, to insure a complete mixture before the portion for analysis is removed.

Dehydration. 8. The material may be tested for distillation without dehydration, if water is present not to exceed 2.0 per cent. If water is present in excess of 2.0 per cent, the bituminous material shall be dehydrated before distillation in accordance with the method for dehydration as given in Sections 2 to 4 of the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials.[1]

III. PROCEDURE

Assembling Apparatus for Distillation Test.

9. (*a*) The flask shall be supported on a tripod or rings over two sheets of 20-mesh gauze, 150 mm. square, as shown in Fig. 3. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the neck with the top of the bulb level with the lowest point of juncture of the tubulature and neck of the flask.

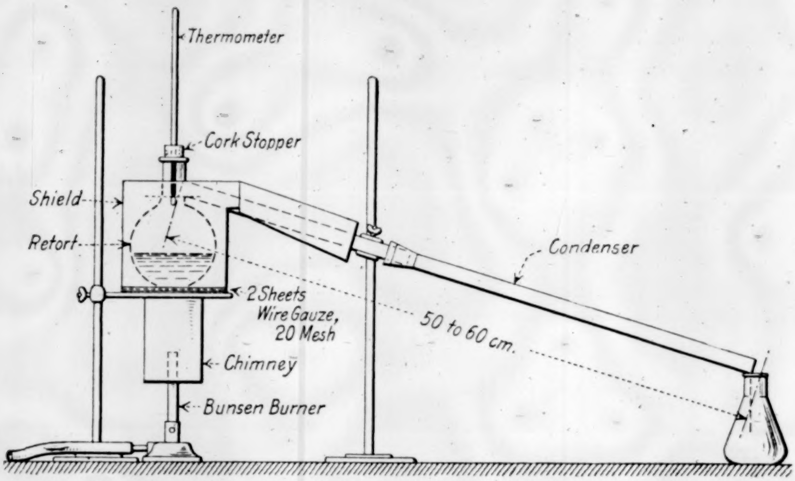

FIG. 3.—Distillation Apparatus Assembly.

(*b*) The axis of the flask through the neck shall be vertical.

(*c*) The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm. The burner should be protected from draughts by a suitable shield or chimney (see Fig. 3).

Distillation Test.

10. (*a*) One hundred grams (100 g. ± 0.1 g.) of the sample shall be weighed into the flask, the apparatus assembled and heat applied so that the first drop comes over in from 5 to 15 minutes. The distillation shall be conducted at the rate of between 50 and 70 drops per minute and the distillate collected in weighed receivers. The

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[1] 1924 Book of A.S.T.M. Standards.

condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. The fraction shall be collected at the points designated by the specifications. The receivers shall be changed when the thermometer indicates the maximum temperature for each fraction. When the maximum specified temperature of the test is indicated by the thermometer, the flame shall be removed and any oil which has condensed in the condenser tube shall be drained into the last fraction.

(*b*) The residue shall remain in the flask with the cork and thermometer in position until no vapors are visible and it shall then be weighed. If tests of the residue are required, the flask shall then be inclined so that the residue will flow around the sides, thus collecting any condensed vapors that may be on the sides of the flask, after which the residue shall be poured into a suitable receptacle and covered. If the residue becomes so cool that it cannot be poured readily from the flask, it shall be reheated to a temperature not exceeding 125° C. by holding the bulb of the flask in a suitable bath and not by the application of flame.

For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used.

(*c*) During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

(*d*) The results shall be reported in per cent by weight of the 100 g. of sample taken. The following fractions are usually reported:

Up to 170° C.
170 to 235° C.
235 to 270° C.
270 to 300° C.
Residue.

TENTATIVE METHOD OF TEST
FOR
DUCTILITY OF BITUMINOUS MATERIALS.[1]

Serial Designation: D 113 – 26 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1926.

Definition. 1. The ductility of an asphalt cement or semi-solid bitumen is measured by the distance to which it will elongate before breaking when two ends of a briquet of the material are pulled apart at a specified rate of speed and at a specified temperature, which for a normal test shall be 5 cm. per minute at 25° C. (77° F.).

APPARATUS.

Mold. 2. The mold shall be as shown in Fig. 1. It shall be made of brass, the ends, b and b′, being known as clips, and the parts, a and a′, as sides of the mold. The dimensions of the mold shall be as follows:

Total length (internal)	7.45 – 7.55 cm.
Distance between clips	2.97 – 3.06 "
Width of clips at mouth	1.98 – 2.02 "
Width of briquette at minimum cross-section (half way between clips)	0.99 – 1.01 "
Thickness of briquette throughout	0.99 – 1.01 "

Water Bath. 3. The water bath shall be maintained at a temperature not varying more than 0.1° C. from 25° C. (77° F.). The volume of water shall be not less than 10 liters and the sample shall be immersed to a depth of not less than 10 cm. and shall be supported on a perforated shelf not less than 5 cm. from the bottom of the bath.

Testing Machine. 4. Any apparatus may be used for pulling the briquette of bitumen apart that is so constructed that the briquette will be continuously immersed in water and the two clips pulled apart at a uniform rate of speed of 5 cm. per minute.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

PROCEDURE.

Melting and Molding.

5. The asphalt cement or bituminous material to be tested shall be completely melted at such a temperature that it will be thoroughly fluid—with ordinary paving asphalt cement this is about 160° C. (320° F.). It shall then be strained through a 50-mesh sieve and, after a thorough stirring, poured into the mold. The mold shall be assembled on a brass plate and so as to prevent the material under test from sticking, the surface of the plate and the interior surfaces of the side pieces *aa′* of the mold shall be thoroughly amalgamated. In filling the mold care shall be taken not to disarrange the parts and thus distort the briquet. In filling, the material shall be poured in a thin stream back and forth from end to end of the mold until it is more than level full. It shall be left to cool to room temperature and then placed in water maintained at 25° C. (77° F.) for 30 minutes, after which the excess of bitumen shall be cut off by means of a hot putty knife or spatula so that the mold shall be just level full.

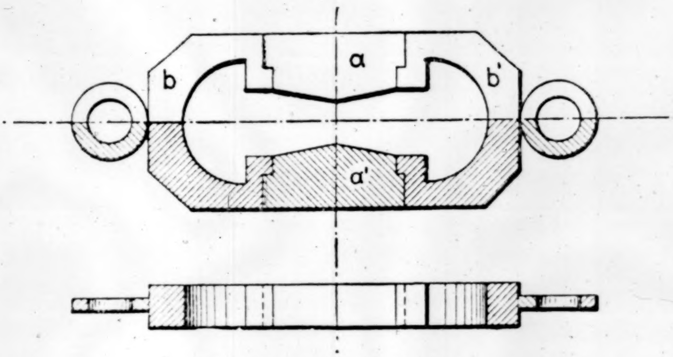

FIG. 1.—Ductility Mold.

Keeping at Standard Temperature

6. The brass plate and mold, with briquet, shall then be placed in the water bath and kept at a temperature of 25° C. (77° F.) for at least 1½ hours, when the briquet shall be removed from the plate and the side pieces detached.

Testing.

7. The rings at each end of the clip shall then be attached to the pins or hooks in the ductility machine and the two clips pulled apart at a uniform rate of 5 cm. per minute (±5 per cent) until the briquet ruptures. The distance through which the clips have been pulled to produce rupture shall then be measured in centimeters. While the test is being made, the water in the tank of the ductility machine

shall cover the sample by at least 2.5 cm. and shall be kept continuously at a temperature within 0.5° C. of 25° C. (77° F.).

A normal test is one in which the material between the two clips pulls out to a point or thread until rupture occurs at the point where the thread has practically no cross-sectional area. The average of three normal tests shall be taken and reported as the ductility of the sample.

If a normal test is not obtainable on three successive tests, the ductility should be reported as being unobtainable under the conditions of the test.

TENTATIVE METHOD OF TEST
FOR
RESIDUE OF SPECIFIED PENETRATION[1]

Serial Designation: D 243 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

Scope. 1. This method of test covers the determination of percentage of residue having a specified penetration at 100 g., 5 seconds, 25° C. (77° F.), obtained by heating a road oil or a semi-solid asphalt having a penetration of more than 100, at a temperature of 249 to 260° C. (480 to 500° F.). When the penetration of the residue is not otherwise stated it shall be understood to be 100. The residue obtained is available for tests as desired.

I. APPARATUS

Container. 2. The container for holding the sample to be tested shall be a flat-bottom, cylindrical seamless tin box, 70 mm. ($2\frac{3}{4}$ in.) in diameter and 45 mm. ($1\frac{3}{4}$ in.) in depth.[2]

Heating Bath. 3. The heating bath shall be a cast-iron air-bath permitting the immersion of the container to a depth of $1\frac{1}{4}$ in. through an opening $\frac{1}{16}$ in. larger in diameter than the container. It shall support the container $\frac{1}{4}$ in. above the hot plate and with at least $\frac{1}{4}$ in. free air space between the sides of the container and of the air-bath below the opening. A suitable air-bath is shown in Fig. 1.

Hot Plate. 4. The air-bath shall be heated upon a suitably mounted hot plate, heated either electrically or by means of a gas flame. The plate shall be capable of maintaining the sample continuously at the required temperature, and apparatus necessary to fulfill this requirement, such as rheostat or gas pressure regulator, shall be provided.

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[1] Criticisms of this Tentative Method are solicited, and should be directed to Mr. Prevost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] These requirements are fulfilled by the Gill style flat bottom seamless ointment box, deep style, 6-oz. capacity, manufactured by the American Can Co.

Thermometer. 5. The thermometer shall conform to the following requirements.[1] These specifications cover a special thermometer graduated to either Centigrade or Fahrenheit degrees as specified, the ranges being −6 to +400° C., or +20 to +760° F., respectively.

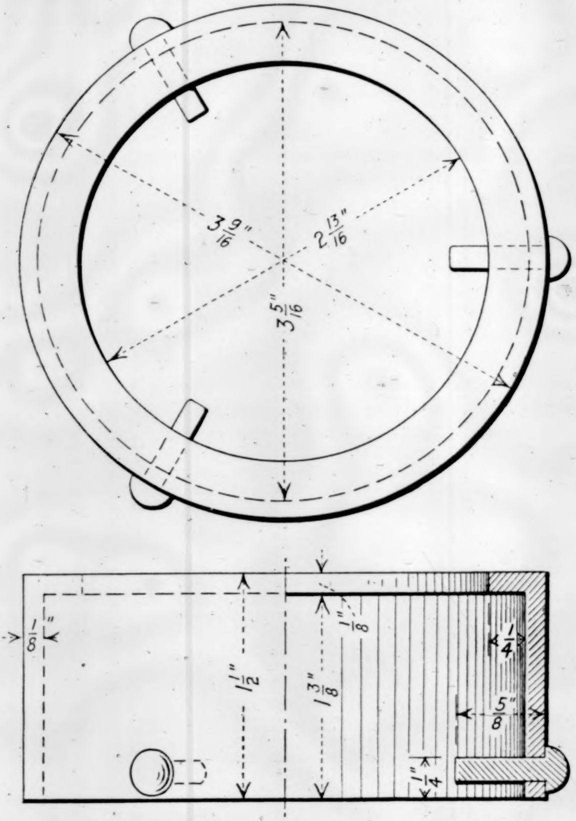

FIG. 1.—Cast-Iron Air-Bath.

TYPE: Etched stem, glass.
LIQUID: Mercury.
RANGE AND SUBDIVISION: −6 to +400° C. in 2° C. or +20 to +760° F. in 5° F.
TOTAL LENGTH: 303 to 307 mm. (11.92 to 12.08 in.).
STEM: Plain front, enamel back, suitable thermometer tubing.
Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).
BULB: Corning normal or equally suitable thermometric glass.
Length, not over 13 mm. (0.51 in.).
Diameter, not greater than stem.

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[1] These specifications are the same as for the open cup flash point thermometer specified in the Standard Method of Test for Flash and Fire Points by Means of Open Cup (Serial Designation: D 92), 1924 Book of A.S.T.M. Standards.

DISTANCE TO –6° C. OR 20° F. LINE FROM BOTTOM OF BULB: 40 to 50 mm. (1.57 to 1.97 in.)

DISTANCE TO 400° C. OR 760° F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Red glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. The first and each succeeding 10° F. line to be longer than the intermediate lines. Graduations to be numbered at each multiple of 20°.

IMMERSION: 25 mm. or one inch. The words "1-in. immersion" on Fahrenheit thermometers or "25-mm. immersion" on Centigrade thermometers and a line around the stem 25.4 mm. or 1.00 in. above the bottom of the bulb shall be etched on the thermometer.

SPECIAL MARKING: "A.S.T.M. Open Flash" a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale when the thermometer is standardized as provided below shall not exceed 1° C. up to 372° C. or 2.5° F. up to 700° F.

STANDARDIZATION: The thermometer shall be standardized at the ice point and at intervals of approximately 100° F. for 25-mm. or 1-in. immersion and for the following temperatures of the emergent mercury column:

THERMOMETER READING		AVERAGE TEMPERATURE OF EMERGENT MERCURY COLUMN	
100° C.	200° F.	44° C.	110° F.
150° C.	300° F.	54° C.	129° F.
200° C.	400° F.	64° C.	150° F.
250° C.	500° F.	77° C.	175° F.
300° C.	600° F.	91° C.	205° F.
350° C.	700° F.	108° C.	240° F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature between 360 to 370° C. or 680 to 700° F. for 24 hours, the accuracy shall be within the limit specified.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. Open Flash, –6 to +400° C." or "A.S.T.M. Open Flash, +20 to +760° F.," according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

II. PREPARATION OF SAMPLE

Preparation of Sample.

6. The sample as received shall be thoroughly stirred and agitated, to insure a complete mixture before the portion for testing is removed.

III. PROCEDURE

Procedure. 7. One hundred grams (100.00 ± 0.10 g.) of the material to be tested shall be weighed into a tared container, which shall then be placed in the air-bath in position to be heated by the hot plate. The thermometer shall be supported in the sample equi-distant from the sides of the container and with the bottom of the bulb neither more than $\frac{1}{4}$ in. above nor touching the bottom of the container. The bulb shall be completely immersed in the sample throughout the heating. An assembly of the apparatus is shown in Fig. 2.

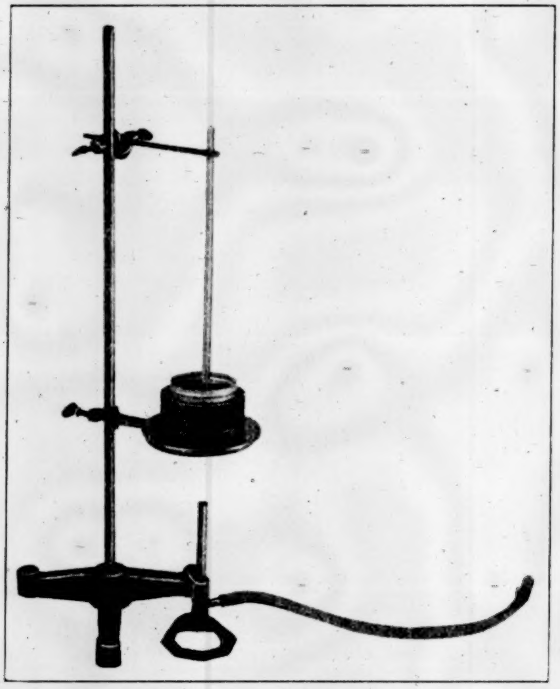

FIG. 2.—Assembly of Apparatus.

8. The sample should be heated as rapidly as possible, to prevent foaming, to atemperature of 249° C. (480° F.) and during the evaporation, the temperature shall be maintained between 249° C. (480° F.) and 260° C. (500° F.). The sample shall be stirred with the thermometer from time to time to prevent local overheating and, to maintain a homogeneous sample, all cakes of hardened bitumen which form at the sides of the container shall be fluxed in the sample.

An experienced operator can judge approximately what percentage of residue he should obtain to secure the desired penetration.

When it is supposed that the residue will show the required penetration, the bitumen on the thermometer which may be readily scraped off shall be returned to the container, which then shall be removed from the air-bath, cooled and weighed. The penetration of the residue shall then be determined in accordance with the Standard Method of Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials.[1]

9. It frequently is necessary to make several trials before a residue of the required penetration is obtained. If it is determined to be greater than that required, all water shall be removed from the container and the surface of the sample, and the heating and determination of penetration may be repeated as before. Ordinarily a residue shall be considered as satisfactorily obtained when its penetration is within 15 of that desired, and its percentage by weight of the original sample shall be calculated. When it is necessary to determine more precisely the percentage of residue having the specified penetration, such a percentage shall be computed by interpolation between percentages of two residues, one having a penetration greater and one having a penetration lower than that specified. The percentage shall be reported as:

Percentage of residue of .... penetration (determined ....) stating, first, the specified penetration, and second, the penetration actually determined for the sample tested or calculated by interpolation.

IV. PRECAUTIONS

10. Certain types of road oil will readily form rings of hard asphalt at the side of the container. Great care should be taken that this material be completely fluxed in the sample before the penetration of the residue is determined.

V. ACCURACY

11. The results of the test shall be considered as correct within a range of 1.0 per cent.

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[1] A.S.T.M. Standards Adopted in 1925.

TENTATIVE METHODS OF TESTING BITUMINOUS EMULSIONS[1]

Serial Designation: D 244 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

1. For testing purposes, emulsions shall be classified as follows:

I. Emulsified light oils or liquid petroleum products intended for dust laying purposes.

II. Emulsified asphaltic materials, the asphalt content of which is of a consistency suitable for construction or repair.

(*a*) Containing little or no mineral matter.

(*b*) Containing appreciable quantities of mineral matter.

METHOD FOR DETERMINING MISCIBILITY OF BITUMINOUS EMULSIONS WITH WATER

(APPLICABLE TO BOTH CLASSES I AND II)

2. To about 50 cc. of the emulsion shall be gradually added about 150 cc. of distilled water, stirring the mixture while adding the water. The temperature is not important but should be between 21 and 25° C. (70 and 79° F.). The mixture shall be allowed to stand for 2 hours and then examined for any appreciable separation.

STONE COATING TEST

(APPLICABLE ONLY TO EMULSIONS OF CLASS II (*a*))

3. Four hundred and sixty-five grams of clean stone ($\frac{1}{4}$ to $\frac{3}{4}$ in. in size, not more than 5 per cent passing a $\frac{1}{4}$-in. screen and 100 per cent passing a $\frac{3}{4}$-in. screen), see Tentative Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction (Serial Designation: D 63 – 23 T) of the American Society for Testing Materials,[2] of either trap or hard limestone shall be placed

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[1] Criticisms of these Tentative Methods are solicited, and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 441 Lexington Ave., New York City.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I., p. 709 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 492.

in a 10-mesh sieve, drenched and washed with distilled water, allowed to drain for 3 minutes and transferred to a suitable pan in which the mixture is to be made. (A 6-in. hemispherical iron dish has been found suitable and satisfactory for this purpose.) Thirty-five grams of the emulsion shall then be added to and mixed vigorously with the stone for 3 minutes. (A steel spatula is satisfactory for mixing.) There shall be no signs of appreciable separation of the asphalt contained in the emulsion during the 3-minute mixing period.

METHOD FOR DETERMINATION OF WATER, OIL DISTILLED WITH WATER AND PREPARATION OF ASPHALTIC BASE FOR FURTHER TESTS

(A) Method Applicable to Emulsions of Class II (a) Only

4. The apparatus shall consist of a copper still, 6 in. by $3\frac{1}{2}$ in. in inside diameter with an air adjustable ring burner to fit the still. The still shall be provided with a connecting tube of approximately 12-mm. diameter glass tubing, a tin shield, a condenser trough, a condenser tube, and a suitable graduated cylinder. A thermometer 0 to 400° C. shall be provided conforming to the requirements for the thermometer specified in Section 10 (*e*) of the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials.[1] The apparatus shall be set up as shown in Fig. 1. The still shall be charged with 200 g. of the well-mixed sample. An oiled paper gasket shall be applied to the flange at the top of the still and the cover clamped on securely. The thermometer shall be placed in position so that the tip of the bulb is $\frac{1}{2}$ in. from the inside bottom of the still. A gentle heat shall be applied to the top of the still by the ring burner. Just sufficient heat shall be applied to the connecting tube to prevent condensation of water therein.

The heat shall be applied to the extreme upper part of the still, until practically all of the water has distilled over, or until a temperature of 121° C. (250° F.) has been reached. The ring burner shall then be lowered very gradually to a position midway between the top and bottom of the still and held there until the temperature is about 176° C. (349° F.). The ring burner shall then be lowered more rapidly to within $\frac{1}{4}$ in. of the bottom of the still and the temperature then raised to 260° C. (500° F.) and maintained for 15 minutes. This period of heating is important to insure a smooth homogeneous residue in the still.

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[1] 1924 Book of A.S.T.M. Standards.

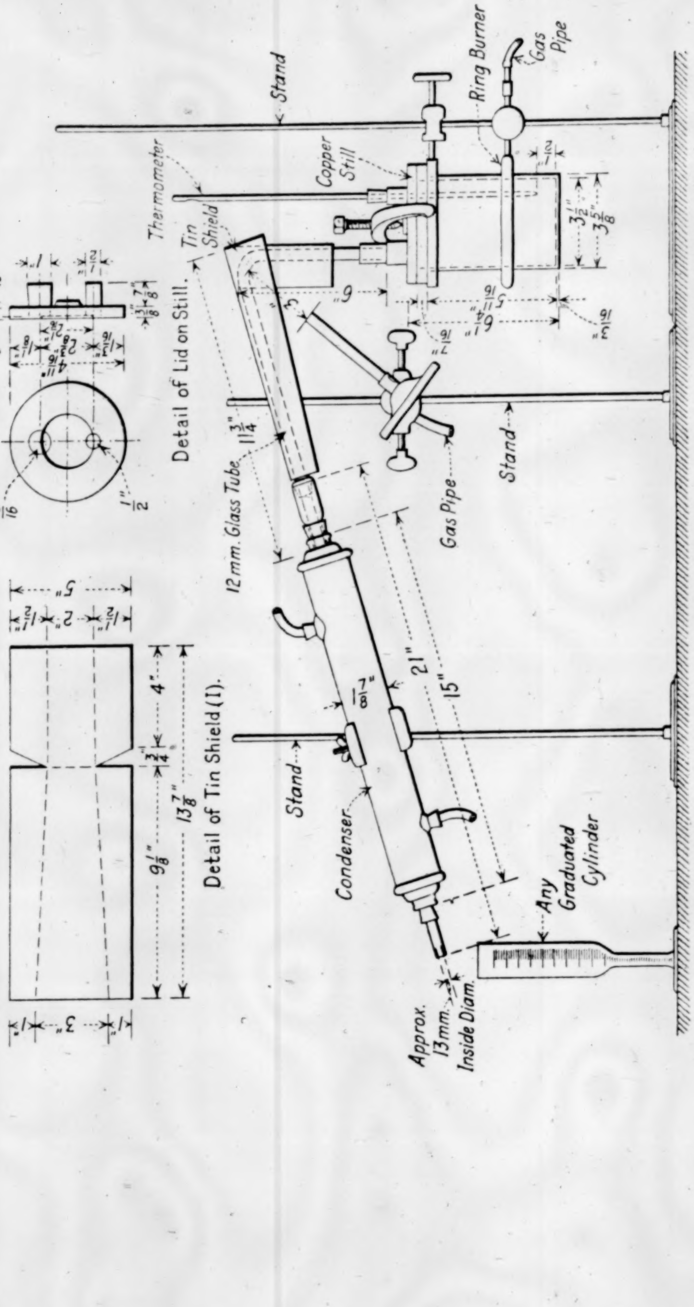
Stand
Ring Burner
Gas Pipe
Copper Still
Thermometer
Tin Shield
Detail of Lid on Still.
3/16"
1"
1/2"
1/8"
7/8"
3/8"
2 1/8"
4 11/16"
2 3/8"
1 1/16"
13/16"
1/2"
12 mm. Glass Tube
11 3/4"
9"
5 11/16"
6 1/4"
7/16"
3/16"
3 1/2"
3 5/8"
1/2"
Gas Pipe
Stand
Detail of Tin Shield (1).
5"
1 1/2"
2"
1 1/2"
4"
3/4"
9 1/8"
13 7/8"
1"
3"
1"
1 7/8"
21"
15"
Stand
Condenser
Any Graduated Cylinder
Approx. 13 mm. Inside Diam.

FIG. 1.—Assembly for Distillation Test for Bituminous Emulsions.

The cover shall then be removed from the still and the hot residue poured into a ductility mold and into a standard 3-oz. tin box for the penetration test, the receptacles being left uncovered. While cooling, any excess shall be poured into suitable containers for any additional tests desired.

Any water or oil remaining in the condenser tube shall be forced out carefully into the graduated cylinder, by means of a rubber stopper fixed on the end of a long rod.

The distillation should be completed in not less than 1 hour and in not more than 1¼ hours.

If the residue is not homogeneous and appears granular, it shall be rejected and the distillation repeated upon a fresh sample, maintaining the temperature at 260° C. (500° F.) for slightly more than 15 minutes.

The number of cubic centimeters of water divided by 2 is the per cent by weight of water.

The weight of residue remaining in the still divided by 2 is the percentage of non-volatile matter under the conditions of this test.

The sum of the percentage of water and non-volatile matter deducted from 100 represents distilled oils.

(*B*) *Method Applicable to Emulsions of Class II* (*b*)

Water.—The water shall be determined by the distillation method above described.

Oils.—Two 50-g. samples of well-mixed emulsion shall be placed in a standard 3-oz. tin box, in an oven at 163° C. (325° F.) for 5 hours, and the loss determined. If the loss is greater than the percentage of water (see preceding paragraph) it would indicate the presence of volatile oils and the difference in the two determinations would closely approximate the percentage of volatile oil.

The residue of the 50-g. sample shall be dissolved in benzol, filtered, and the filtrate evaporated on a water bath until practically all the benzol is evaporated, then placed in an oven at 105° C. (221° F.) for 30 minutes and finally heated on a hot plate to 121° C. (250° F.) with constant stirring. The consistency, ductility or other tests desired are made upon this residue.

Mineral Matter.—The mineral matter on the filter paper from the extraction shall be dried and weighed or a separate determination on a smaller sample of the original emulsion may be made.

TENTATIVE METHOD OF TEST
FOR
FINENESS OF POWDERED COAL[1]

Serial Designation: D 197 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society, and is subject to annual revision.

ISSUED, 1924; REVISED, 1926.

I. APPARATUS

Sieves. 1. Sieves Nos. 16, 30, 50, 100, and 200 of the U. S. Standard Sieve Series, each with a close-fitting pan and cover, shall be used. Wire cloth for the sieves shall be woven (not twilled) from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder, or so made that the material will not catch. The sieve frames shall be circular, about 20 cm. (8 in.) in diameter and about 5 cm. (2 in.) or 2.5 cm. (1 in.) between the top of the frame and the cloth. The sieve openings and wire diameters shall conform to the requirements as given in Table I.

TABLE I.—REQUIREMENTS FOR SIEVE OPENINGS AND WIRE DIAMETERS WITH PERMISSIBLE VARIATIONS.

Designation		Sieve Opening		Wire Diameter		Tolerance in Average Opening, per cent	Tolerance on Wire Diameter, per cent		Tolerance in Maximum Opening, per cent
U. S. Standard Sieve Series Number	Micron Designation	mm.	in.	mm.	in.		Under	Over	
16	1190	1.19	0.0469	0.54	0.0213	±3	15	30	10
30	590	0.59	0.0232	0.33	0.0130	±5	15	30	25
50	297	0.297	0.0117	0.188	0.0074	±6	15	35	40
100	149	0.149	0.0059	0.102	0.0040	±6	15	35	40
200	74	0.074	0.0029	0.053	0.0021	±8	15	35	60

NOTE.—These sieve specifications conform to the Standard Specifications for Sieves for Testing Purposes (Serial Designation: E 11) of the American Society for Testing Materials,[2] which specifications also give methods of testing the wire cloth.

Containers. 2. (*a*) *For Collecting Gross Sample.*—The containers shall be of metal of about 8 to 10-liter capacity, provided with tightly fitting covers.

NOTE.—Two-gallon milk cans are suitable for this purpose.

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[1] Criticisms of this Tentative Method are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

[2] A.S.T.M. Standards Adopted in 1926.

(*b*) *For Collecting Laboratory Sample.*—The containers may be of metal or glass of about one-liter capacity, provided with tightly fitting covers.

II. SAMPLING

3. The coal pulverized, per mill, during the period of one hour shall be considered a unit for sampling. **Unit of Sampling.**

A. Multiple System

In the multiple powdered coal system, the coal after pulverization is conveyed into bins.

4. Not less than 2 kg. of representative powdered coal shall be collected as it is being discharged from the pulverizer. This is best accomplished by collecting increments of not more than 200 g. at regular intervals by means of a scoop. The increments shall be placed into a can of about 8 to 10-liter capacity, provided with a tightly fitting cover. **Sampling.**

5. The gross sample shall be placed on a sheet of rubber or oilcloth, and thoroughly mixed by raising first one corner of the cloth and then the other so as to roll the coal over and over at least 100 times. After mixing, the sample shall be coned and quartered. The operations of mixing, coning, and quartering shall be continued if necessary until the sample is reduced sufficiently so that all of one of the quarters weighs about 500 g., which coal shall constitute the laboratory sample. The laboratory sample shall be transferred to a metal or glass container of about one-liter capacity, provided with a tightly fitting cover. **Preparation of Sample.**

NOTE.—The operations of mixing, coning and quartering are described and illustrated in the Standard Methods of Sampling Coal (Serial Designation: D 21) of the American Society for Testing Materials.[1]

B. Unit System

In the unit powdered coal system, the coal during and after being pulverized is at once mixed with air and delivered to the furnace. It is difficult to obtain representative samples, as it is necessary to sample the coal from a moving stream of coal and air inside the pipe between the pulverizer and the furnace. It is preferable to collect such samples from vertical pipes if possible, as in horizontal pipes considerable segregation takes place, the coarser particles tending to flow along the bottom of the pipes.

6. (*a*) The sampling device shall consist of a 1-in. thin-walled brass tube, with one end bent at a right angle or provided with a 90-deg. elbow and short length of tube. At the other end of the **Sampling Device.**

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[1] 1924 Book of A.S.T.M. Standards.

sampling tube a vacuum-sweeper bag shall be tightly attached. The inside of the sampling tube shall have no projections to interfere with the flow of coal.

(*b*) The sampling tube shall be inserted into the powdered coal pipe through a stuffing-box in such a manner that the opening of the sampling tube shall be directed against the stream of coal and air, and permit moving back and forth across the entire diameter of the coal pipe. If the sample must be taken from a horizontal pipe, the sampling tube shall be inserted through the top of the coal pipe, in such a manner as will permit moving the tube back and forth from top to bottom along the vertical diameter of the pipe.

Sampling. 7. In collecting the sample, the sampling tube shall be moved uniformly back and forth along the diameter of the pipe. In order to permit ready elimination of air from the bag, the vacuum-cleaner bag shall not be filled more than about one-fifth full at any time. Sampling shall be continued at regular intervals until a gross sample of not less than 5 kg. of coal is collected.

Preparation of Sample. 8. The gross sample shall be mixed, coned and quartered, and reduced in the same manner as described for the multiple powdered coal system.

III. PROCEDURE

Drying. 9. The entire laboratory sample shall be air dried in a drying oven at 10 to 15° C. above room temperature. The drying shall be continued until the loss in weight is not more than 0.1 per cent per hour.

Reducing Sample. 10. After air drying, the sample shall be thoroughly mixed by rolling over and over at least 100 times on a sheet of rubber or oilcoth, as described for the mixing of the gross sample. The sample, after mixing, shall be spread out to a depth of about ½ in. and portions, representing a section from the top of the coal to the mixing cloth, shall be taken with a spatula at regular intervals.

Procedure. 11. A 50-g. sample of the air-dried coal shall be placed on the No. 200 sieve, to which a pan and cover shall be attached. The sieve shall be held in one hand in a slightly inclined position, so that the sample will be well distributed over the sieve, while at the same time the operator shall gently strike the side about 150 times per minute against the palm of the other hand on the up stroke. Every 25 strokes the sieve shall be turned about one-sixth of a revolution in the same direction. The sieve shall be held over a sheet of glazed white paper during the sieving operation, so as to detect any loss that might result from accidental spilling of a portion of the sample, in which case another sample shall be taken.

After sieving for one minute, the sieve pan shall be removed, and the material which has passed through the sieve discarded. The side of the sieve shall be tapped with a brush handle, and the coal adhering to the under side of the wire cloth brushed off. During the operation of tapping and brushing, the sieve cover shall remain on the sieve so as to prevent any loss of material over the side of the sieve.

NOTE.—A 1-in. bristle brush is satisfactory for brushing the under side of the wire cloth.

The sieve pan shall be replaced, and the sieving continued for two minutes; then the tapping and brushing shall be repeated, and again repeated after two minutes of additional sieving. The operation shall then be continued in the usual manner, omitting the tapping and brushing, until the amount passing through in one minute of continuous sieving is about 0.1 g. Each time, before weighing the material passing through the sieve, the side of the sieve shall be tapped with the brush handle in order to remove any material adhering to the under side of the wire cloth. The cover of the sieve shall then be removed, and the residue remaining on the sieve carefully removed. The sieve shall be inverted over a piece of glazed white paper, and the wire cloth cleaned by carefully brushing the under side. The material thus removed from the wire cloth shall be added to the residue removed from the sieve.

After cleaning the sieve, the residue shall be placed thereupon, the sieve pan and cover attached, and the sieving resumed in the usual manner, omitting the operations of tapping and brushing, until not more than 0.05 g. passes through in one minute of continuous sieving, when the sieving shall be considered to be finished. The sieve shall be inverted and cleaned as before, and the residue weighed.

12. The residue shall then be successively sieved on the Nos. 100, 50, 30, and 16 sieves. Sieving shall be continued in the usual manner, omitting the tapping and brushing, until not more than 0.05 g. passes through in one minute of continuous sieving, when the sieving shall be considered finished. The sieve shall then be inverted, cleaned, and the residue weighed as described for the No. 200 sieve.

NOTE.—As the fine material which tends to clog the meshes of the sieves has been removed by sieving through the No. 200 sieve, it is not necessary to brush the under side of the wire cloth or clean the sieves during the sieving operation, as was done for the No. 200 sieve.

13. The fineness shall be calculated from the weights of the residues on the sieves, and shall be expressed as percentages of the weight of the original sample. Sieving value corrections for the

No. 200 sieves, as determined by the U. S. Bureau of Standards, shall be applied to the material sieved on the No. 200 sieves. The fineness test shall be reported as follows:

	PER CENT
Retained on No. 16 sieve.	....
" " No. 30 sieve, passing No. 16 sieve.	....
" " No. 50 sieve, " No. 30 sieve.	....
" " No. 100 sieve, " No. 50 sieve.	....
" " No. 200 sieve, " No. 100 sieve.	....
" No. 200 sieve.	....

NOTE.—In applying the sieving value corrections, the graphical or analytical methods for obtaining such corrections for sieves which have been tested with a single standard sample shall be used. These methods are described in U. S. Bureau of Standards *Technologic Paper No. 42*, pp. 45–47 (1914).

Duplicate Determinations. 14. Duplicate determinations by the same operator, using the same sieves, shall check within 1 per cent on all sizes. Different operators, using different sieves, shall check within 3 per cent on the material sieved on the No. 200 sieves.

NOTE.—Until such time as standard materials are available for determining sieving values of Nos. 100, 50, 30, and 16 sieves, it is not feasible to specify check limits for the sizes as determined with these sieves, when different sieves are used.

RAPID ROUTINE METHOD BY MACHINE SIEVING

For routine testing, mechanical sieving devices, by which a number of sieves are shaken at the same time, afford a convenient method of making fineness tests. The hand-sieving method shall however be the standard method of test. The results obtained by machine sieving should be compared to those obtained by hand sieving, to determine whether the sieving action of the machine used is practically the same as by hand sieving, for the coal being sieved.

The same sieves should be used as specified for hand sieving, and each sieve should be provided with a close-fitting pan and cover to prevent possible loss of material during sieving. A 50-g. sample of air-dried coal should be placed on each sieve (previously tared), and the sieves shaken until not more than about 0.1 g. passes through the finest sieve of the series in the machine in one minute of continuous sieving. The sieves should then be removed from the machine and the under surface of each sieve brushed clean. Sieving should then be resumed until not more than 0.1 g. passes through the finest sieve of the series in the machine in one minute of continuous sieving, when the test shall be considered finished, after which the sieves should be cleaned as before and weighed on a balance sensitive to 0.1 g. The fineness should be calculated and reported as in the hand-sieving method.

TENTATIVE DEFINITIONS
OF
TERMS RELATING TO COAL AND COKE[1]

Serial Designation: D 121 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1924, 1926.

Proximate Analysis.—In the case of coal and coke, determination by prescribed methods of moisture, volatile matter, fixed carbon (by difference), and ash.

NOTE.—Unless otherwise specified, the term "proximate analysis" does not include determinations of sulfur or phosphorus or any determinations other than those named.

Ultimate Analysis.—In the case of coal and coke, the determination of the carbon and hydrogen in the material, as found in the gaseous products of its complete combustion, the determination of sulfur, nitrogen and ash in the material as a whole, and the estimation of oxygen by difference.

NOTE 1.—Determination of phosphorus is not by definition a part of ultimate analysis of coal or coke, but may be specified when desired.

NOTE 2.—When the analysis is made on an undried sample, part of the hydrogen and oxygen as determined is present in the incidental or free moisture accompanying the coal. Therefore, in comparing coals on the basis of their ultimate analysis, it is advisable always to state the analysis on both the "as-received" and dry basis.

NOTE 3.—Inasmuch as some coals contain mineral carbonates, and practically all contain clay or shale bearing water of composition, a part of the carbon, hydrogen and oxygen found in the products of combustion may arise from these mineral constituents.

Moisture.—Essentially water, quantitatively determined in a material by definite prescribed methods which may vary according to the nature of the material.

NOTE 1.—Such methods may not determine all of the water present.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, U. S. Bureau of Mines, 4800 Forbes St., Pittsburgh, Pa.

NOTE 2.—In the case of coal and coke the methods employed shall be those prescribed in the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) and in the Standard Methods of Laboratory Sampling and Analysis of Coke (Serial Designation: D 37), respectively, of the American Society for Testing Materials.[1]

Ash.—Inorganic residue remaining after ignition of combustible substances, determined by definite prescribed methods.

NOTE 1.—The ash as thus defined may not be identical in composition or quantity with the inorganic substances present in the material before ignition.

NOTE 2.—In the case of coal and coke the methods employed shall be those prescribed in the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) and in the Standard Methods of Laboratory Sampling and Analysis of Coke (Serial Designation: D 37), respectively, of the American Society for Testing Materials.[1]

Volatile Matter.—Those products, exclusive of moisture, given off by a material as gas or vapor, as determined by definite prescribed methods, which may vary according to the nature of the material.

NOTE.—In the case of coal and coke the methods employed shall be those prescribed in the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) and in the Standard Methods of Laboratory Sampling and Analysis of Coke (Serial Designation: D 37), respectively, of the American Society for Testing Materials.[1]

Fixed Carbon.—In the case of coal, coke and bituminous materials, the solid residue other than ash, obtained by destructive distillation, as determined by definite prescribed methods.

NOTE 1.—It is made up principally of carbon, but may contain appreciable quantities of sulfur, hydrogen, nitrogen and oxygen.

NOTE 2.—In the case of coal and coke the methods employed shall be those prescribed in the Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22) and in the Standard Methods of Laboratory Sampling and Analysis of Coke (Serial Designation: D 37), respectively, of the American Society for Testing Materials.[1]

Coke.—The infusible, cellular, coherent solid material obtained from coal as the residue from its destructive distillation.

NOTE 1.—Such material obtained from the destructive distillation of petroleum or petroleum residues is known as "petroleum coke."

NOTE 2.—Such material obtained from the destructive distillation of coal-tar pitch is known as "pitch coke."

Beehive Coke.—Coke manufactured in beehive, rectangular, or similar forms of ovens in a horizontal bed, where heat for the coking process is secured by combustion within the oven chamber.

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[1] 1924 Book of A.S.T.M. Standards.

By-Product Coke.—Coke manufactured with attendant recovery of by-products, in ovens that are heated externally, and having properties making it available for metallurgical purposes.

Coke Breeze.—The fine screenings from crushed coke or from coke as taken from the ovens, of a size varied in local practice but usually passing a ½-in. or ¾-in. screen opening.

Dry Coke.—Coke which has been dried to constant weight at temperatures not less than 104° C. nor more than 200° C. in the case of lump coke, and between 104 and 110° C. in the case of coke passing a No. 60 sieve, in accordance with methods of determining moisture prescribed in the Standard Methods of Laboratory Sampling and Analysis of Coke (Serial Designation: D 37) of the American Society for Testing Materials.[1]

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[1] 1924 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL JOIST, PLANKS, BEAMS, STRINGERS AND POSTS[1]

Serial Designation: D 245 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926

A. STRUCTURAL GRADES OF LUMBER AND TIMBER AND THE METHOD OF THEIR DERIVATION

Purpose. 1. The purpose of structural grades is to offer means for selecting structural material for strength, and for uniformity in strength, in order that appropriate working stresses may be assigned for its use.

Factors of Strength. 2. The most important factors which influence the strength of structural material are the size, number and location of defects, and the extent of exposure to moisture during use. These factors must all be considered in design or grading if the maximum utilization is to be obtained from the material used.

Structural Grades and Strength. 3. Structural grades control defects by limiting their size and location in accordance with their effect upon strength. Working stresses for each species are recommended by the Forest Products Laboratory, U. S. Forest Service, and take into consideration the allowable defects, the moisture content as determined by conditions of use, and, in the case of southern yellow pine and Douglas fir, rate of growth and percentage of summerwood.

Moisture. 4. Moisture affects the strength of structural timbers both directly and indirectly. The direct effect of loss of moisture is the stiffening and strengthening of the wood fibers. This increase in strength, however, is accompanied by checking, splitting, warping and twisting; as a consequence, some of the strength due to drying is lost. Timbers are also subject, during use, to varying conditions of moisture, from the dry location of a heated building, to the continually wet condition of some pier and dock timbers. All of these conditions are taken into account in recommending working stresses under different conditions of use.

Size Effects. 5. In dimension material, 4 in. and less in thickness, the development of defects during seasoning does not offset the increase in strength from drying as much as in larger sizes, and in these sizes used in dry locations, higher working stresses in extreme fiber in bending can be recommended than in pieces of larger size having proportionately equivalent defects.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U.S. Forest Products Laboratory, Madison, Wis.

Defects. 6. The principal defects which must be limited in structural grades are: knots, shakes and checks, and angle of grain.

Influence of Knots. 7. The influence of a knot is determined by its location in a beam and the area of its projection on the cross-section of the piece, the method of measurement being such as to give the best approximation of this influence. Knots in posts and heavy beams, which are likely to show only on one face or to run diagonally through the piece, reduce the strength in practically direct proportion to their size as measured. In dimension sizes, such as joist, in which the knot is likely to run directly through the piece, the strength is measured by the square of the effective depth, assuming the knot in its worst position, near the edge of the piece, and the reduction in strength due to the knot is approximately twice the ratio of the size of the knot to the width of the face. In similar material used flat, as plank, the influence of a knot is directly proportional to the size, as on the top and bottom edges of beams.

Location of Knots, Joist and Plank. 8. Knot limitations on edges of wide faces of dimension sizes, for use as joist, are more severe than would be required for use flat, as plank, the sizes applying along the center lines of the wide faces as joist being those which could theoretically apply at any point across the width if used only as plank. It has been found, however, that under practically all conditions of use, knots along the edges of planks are more objectionable than knots along the center lines and this is recognized in some commercial yard grades of plank in a stricter limitation of knots along the edges of the wide faces than along the center lines. The same knot limitations are applied, therefore, to material to be used either as joist or plank, and the same working stresses are assigned for use either on edge or flat.

Increase in Size of Knots. 9. In both joist and beams, knots reduce strength most along the top and bottom edges through the center portion. The sizes of knots permitted in various portions of a joist or beam are limited in accordance with the stresses, and they are allowed to increase toward the ends and toward the center lines of the vertical faces, no knot, however, being permitted of more than double the size allowed at the point of maximum stress.

Small and Large Knots. 10. There is greater proportional distortion of grain around a large knot than around a smaller one, and shrinkage in seasoning causes greater internal stresses, so knot sizes are increased proportionately to width of faces only up to 6-in. top and bottom faces of beams, 12-in. vertical faces of beams and 12-in. faces of posts. Beyond these widths of face, increase is proportional to the square root of the ratio of the wider faces to these widths. The distribution and aggregate diameter of knots is limited, as well as the maximum size of the single knot.

Knots in Joist and Plank. 11. In joist and plank, the mean or average diameter of a knot is taken as its size. In such thin and relatively wide material, whether used on edge or flat, this is a safe measure of the influence of knots on strength, and has the commercial advantage of being directly applicable to yard grades of lumber. This method of measurement will exclude damaging spike knots, and can be applied to them as well as to round or oval knots.

12. On the top or bottom of a beam, the influence of knots is measured largely by the surface fibers cut. The projection of the knot on a line at a right angle to the edge is, therefore, used. On the vertical face of a beam, the depth to which a knot penetrates is of great importance, while the influence of the number of surface fibers cut, and the amount of grain distortion, is considerably

less important than on the horizontal faces. The smallest diameter of the knot is, therefore, used.

Spike Knots. 13. One of the best examples illustrating the reason for the smallest diameter being taken on the vertical face is the splitting of a boxed-heart timber into two pieces. The long spike knots which might be opened up in this way would be no more injurious to the strength of the two pieces than they would as a single knot in a boxed-heart piece, and the two pieces so cut would be less subject to seasoning checks than a boxed-heart piece.

Knots in Columns. 14. In columns there are two factors: area of cross-section occupied by a knot, which would probably be measured best by the small diameter of the knot, and the influence of bending stresses when the column begins to fail, probably measured best by the projection of the knot. In short columns, the area of the cross-section is of primary importance; as the column gets longer, the factor of bending strength increases in importance until the condition of the Euler formula is reached, when stiffness, on which knots have practically no influence, becomes the ruling factor. The average diameter, therefore, is used as that which applies best to the average condition.

Knots and Holes. 15. In grades for structural uses, no distinction is made between intergrown knots and encased knots or knotholes, observation at the Forest Products Laboratory in recent tests having shown that intergrown knots reduce strength fully as much as encased knots or knotholes.

Shakes and Checks. 16. Shakes reduce the area of a beam acting in resistance to shear, and the limitations placed on shakes are based on this reduction. Checks are limited on the same basis as shakes, and no combination of shakes and checks is permitted which would reduce strength to a greater extent than would the allowable size of either separately.

17. Shakes and checks in Dense Select and Select joist and plank shall not exceed when green one-fourth the width of end nor when seasoned one-third the width of end.

Shakes and checks in Common joist and plank shall not exceed when green four-tenths the width of end nor when seasoned four-ninths the width of end.

Shakes and checks in Dense Select and Select beams and stringers shall not exceed when green one-fourth the width of end nor when seasoned one-third the width of end.

Shakes and checks in Common beams and stringers shall not exceed when green four-tenths the width of end nor when seasoned four-ninths the width of end.

Shakes and checks in Dense Select and Select posts and timbers shall not exceed when green four-tenths the width of end nor when seasoned one-half the width of end.

Shakes and checks in Common Posts and Timbers shall not exceed when green one-half the width of end nor when seasoned six-tenths the width of end.

Slope of Grain. 18. Slope of grain, resulting either from diagonal sawing or from spiral or twisted grain in the log, is limited in accordance with the recommendation of the Forest Products Laboratory, based on the results of detailed study of the effect of cross and spiral grain upon strength, and the weakening of material by checks which invariably develop and, without exception, follow the grain.

Wane and Knots. 19. Wane is limited by such consideration as bearing area, nailing edge, appearance, etc., rather than by effect on strength. The percentage reduction in strength resulting from wane toward the center of a beam is about double the percentage reduction in cross-sectional area. No combination of wane and knots is permitted which would reduce the strength more than the maximum allowable knot. The occurrence of maximum wane and maximum knot in the same cross-section at the center of a beam would be so rare, however, and the effect of allowable maximum wane is so small a percentage of the effect of maximum allowable knot, that the additional reduction in strength beyond the effect of the knot would be slight and it is usually unnecessary to give attention to combination of wane and knot.

Pitch Pockets.

20. Pitch pockets are ordinarily not defects in a structural grade. A large number, however, indicates a general lack of bond, and such a piece should be carefully inspected for shakes.

Heartwood and Sapwood.

21. Heartwood and sapwood have been found by the Forest Products Laboratory to be of equal strength, and no requirement of heartwood need be made when strength alone is the governing factor. Heart requirement, when durability of untreated material under exposure is a factor, as in bridges, trestles, docks and piers, or in damp buildings, or buildings in which conditions of high humidity prevail, may be specified in any grade, according to exposure and use. When preservative treatment is to be applied, there should be no restriction as to sapwood, as a large amount of sapwood is to be preferred.

Density and Strength.

22. The density of the wood substance of all species is practically the same. The dry weight is, therefore, a measure of the amount of wood substance present; and on the amount of wood substance present depends the strength of the clear wood. No pieces of exceptionally light weight are permitted in the Select grades, but light weight pieces otherwise of Select grade may be accepted in the Common grades.

Density and Summerwood.

23. In southern pine and Douglas fir, the proportion of summerwood, the dark portion of the annual ring, furnishes a practical means of estimating density. Selection of these species for density, to the extent that dense material is commercially available, assures material of the highest character from the standpoint of strength, and uniformity in strength, in the clear wood.

Rate of Growth and Strength.

24. Selection of these species for rate of growth is not as great an assurance of increased strength as selection for percentage of summerwood, but for many purposes selection for rate of growth will assure material of suitable type. Close grain, that is, not less than six nor more than twenty annual rings per inch, is required in the Select Structural grades of these species.

Contrast Summerwood and Springwood.

25. In acceptance for density the contrast in color between summerwood and springwood should be distinct. Absence of contrast occasionally occurs in bands of growth rings which appear on the whole darker in color than the adjacent material. The summerwood merges into the springwood abnormally with a gradual change of color, leaving practically no material which has the normal appearance of springwood. Such material has been called by a number of names, including proud wood, red wood, and compression wood. It has a decided end shrinkage, is weak in tension, and even a small part of a cross-section of this character is undesirable in high-class structural timbers.

Minimum Requirements, Maximum Defects.

26. Structural grades specify minimum requirements and maximum defects, all of which may be present at one time. When a particular piece which is being inspected, therefore, is slightly below the provisions of the grade in some respects but is of average density or above, the relative effect on the properties affected should be given consideration.

Re-inspection. 27. In inspection for density, reasonable variation of opinion between inspectors should be recognized. A fair provision for re-inspection of a particular lot of timbers for density would be that for every three timbers accepted as having one-third or more summerwood, one of the remaining timbers be accepted if having between 30 and $33\frac{1}{3}$ per cent summerwood.

Yard Grades and Cutting Grades. 28. A large percentage of material in standard yard grades of "dimension" and "timbers" will meet the additional requirements of structural grades for joist and plank, and posts and timbers, and material to meet these requirements can easily be selected from local stocks: Select from Select Common and Merchantable grades, and Common from No. 1 Common grade. Beams and stringers vary materially in size and are not stocked extensively. These are essentially special order grades.

Joist and Plank, Beam and Stringers. 29. As previously noted the provisions of the joist and plank grades are such that material graded by them may be used on edge, as joist or rafters, or flat, as scaffold plank or factory flooring. Joist and plank grades apply to material not thicker than 4 in. Material thicker than 4 in. for use in bending should be graded by beam and stringer grades.

Timbers Used as Beams and Stringers. 30. Material to be used for such purposes as caps, bridge ties, etc., where strength in bending is a factor, should be specified in beam and stringer grades although of shape more commonly considered as of timber grades, as the method of measuring knots in post and timber grades makes it impracticable to assign bending stresses to them. Caps and bridge ties are often square or have horizontal faces wider than the vertical faces, in contrast to beams and stringers in which the narrow faces are horizontal faces and the wide faces are vertical, and this should be noted in applying the knot provisions of the beam and stringer grade to such material.

INTRODUCTION TO STRUCTURAL RULES

31. The following rules for Structural Grades conform to the "Basic Provisions for the Selection and Inspection of Softwood Dimension and Timbers Where Working Stresses are Required" accepted at the General Lumber Conference, Washington, D. C., May 1, 1925, as the basis for the preparation of grading rules for structural material.

32. They are complete rules, covering all conditions necessary for consideration in structural grading, and are divided into sections from which combinations are made covering specific purposes and conditions.

33. These specifications may be used for mill orders, selection from or appraisal of stock on hand in either manufacturers', middlemen's or users' stock.

34. The rules cover the following grades and use classifications:

Grades:

DENSE SELECT	Douglas Fir and Southern Pine
SELECT	Douglas Fir and Southern Pine
SELECT	Other Softwood Species
COMMON	All Softwood Species

Uses:

JOIST AND PLANK	Joist, Rafters, Bracing, Scaffold Plank, Factory Flooring, etc.
BEAMS AND STRINGERS	Beams, Girders, Stringers, Bridge Ties, Caps, etc.
POSTS AND TIMBERS	Posts, Sills, Caps, Timbers, etc.

Optional Provisions:

WANE.......................................Where Permissible
SQUARE EDGES..............................Where Required or Desired
HEARTWOOD REQUIREMENTS........For Durability of Untreated Timbers
SAPWOOD PERMISSIBILITY..................For Material to be Treated

Sizes of Joist and Plank (Joist, Rafters, Scaffold Plank, Factory Flooring, etc.):

Nominal thickness..2 to 4 in.
Nominal widths......................................4 in. and wider
Standard thickness.............................S1S or S2S: $\frac{3}{8}$ in. off
Extra Standard thickness....................2 in., S1S or S2S: $\frac{1}{4}$ in. off
Standard widths.........................2 to 7 in., S1E or S2E: $\frac{3}{8}$ in. off
8 in. and wider, S1E or S2E: $\frac{1}{2}$ in. off

Sizes of Beams and Stringers (Beams, Girders, Stringers, etc.):

Nominal thickness...............................5 in. and thicker
Nominal widths....................................8 in. and wider

Sizes of Posts and Timbers (Posts, Caps, Sills, Timbers, etc.):

Nominal sizes.................................6 by 6 in. and larger

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B. SPECIFICATION REQUIREMENTS FOR STRUCTURAL JOIST, PLANK, BEAMS, STRINGERS, AND POSTS

I. TIMBER SIZE REQUIREMENTS

Standard Joist and Plank, Surfaced.

1*A*. Standard structural joist and plank shall be when surfaced S1S or S2S not thinner than the nominal dimension less $\frac{3}{8}$ in. and when surfaced S1E or S2E not narrower than the nominal width less $\frac{3}{8}$ in. for sizes 2 to 7 in., inclusive, and less $\frac{1}{2}$ in. for sizes 8 in. and wider.

Extra Standard Joist and Plank, Surfaced.

1*B*. Extra Standard structural joist and plank, 2-in. size only, shall be when surfaced S1S or S2S not thinner than the nominal dimension less $\frac{1}{4}$ in. and when surfaced S1E or S2E not narrower than the nominal width less $\frac{3}{8}$ in. for sizes 2 to 7 in., inclusive, and less $\frac{1}{2}$ in. for sizes 8 in. and wider.

Beams, Stringers, Posts, Timbers, Surfaced.

1*C*. Structural beams, stringers, posts and timbers shall be when surfaced S1S, S1E, S2S, S4S not smaller than the nominal size less $\frac{3}{8}$ in. for sizes 7 in. and narrower and less $\frac{1}{2}$ in. for sizes 8 in. and wider.

Standard Joist and Plank, Rough.

1*D*. Rough standard structural joist and plank shall be not thinner than the nominal dimension less $\frac{1}{4}$ in. and not narrower than the nominal width less $\frac{1}{4}$ in. for sizes 2 to 7 in., inclusive, and less $\frac{3}{8}$ in. for sizes 8 in. and wider.

Extra Standard Joist and Plank, Rough.

1*E*. Rough extra standard structural joist and plank, 2 in. size only, shall be not thinner than the nominal dimension less $\frac{1}{8}$ in. and not narrower than the nominal width less $\frac{3}{8}$ in. for sizes 2 to 7 in., inclusive, and less $\frac{1}{2}$ in. for sizes 8 in. and wider.

Beams, Stringers, Posts, Timbers, Rough. 1*F*. Rough structural beams, stringers, posts and timbers shall not be smaller than the nominal size less $\frac{1}{4}$ in. for sizes 7 in. and narrower and less $\frac{3}{8}$ in. for sizes 8 in. and wider.

II. GRADE REQUIREMENTS

Sound Wood. 2. This material shall contain only sound wood.

GENERAL

Weight. 3. (*a*) No pieces of exceptionally light weight shall be permitted, except that light weight pieces otherwise of Select grade may be accepted in Common grade.

Shake, Check and Split. (*b*) Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the piece. Checks and splits shall be limited as provided for shakes. No checks or combinations of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

Wane and Knots. (*c*) Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

Cluster Knots. (*d*) Cluster knots and knots in groups are not permitted.

Holes. (*e*) Knot holes and holes from other causes than knots shall be permitted as provided for knots.

Knot Measurement. (*f*) The size of a knot shall be measured on the section of the knot appearing on the surface under consideration.

Mean Diameter. (*g*) When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

Spike Knots. (*h*) Knot sizes specified shall be applied to spike knots as well as to round knots.

Spike Knot Mean Diameter. (*i*) The mean or average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

Joist and Plank

Wide Faces. 4. (*a*) On the wide faces of joist and plank, the measurement of a knot shall be made on the mean or average diameter.

Narrow Faces. (*b*) On the narrow faces of joist and plank, the size of a knot shall be taken as its width between lines parallel to the edges of the piece.

Increase to Ends. (*c*) The size of knots on the narrow faces and edges of wide faces of joist and plank may increase proportionately from the size allowed in the middle third to twice that size at the ends of the pieces.

Increase to Center.

(*d*) The size of knots on the wide faces of joist and plank may increase proportionately from the size allowed at the edge to that allowed at the center line.

Beams and Stringers

Narrow Faces.

5. (*a*) On the narrow or horizontal faces of beams and stringers the size of a knot shall be taken as its width between lines parallel to the edges of the timber.

Wide Faces.

(*b*) On the wide or vertical faces of beams and stringers the smallest diameter of a knot shall be taken as its size.

Edges.

(*c*) Knots on the edges of wide or vertical faces of beams and stringers are limited to the same size as on the adjacent narrow or horizontal faces, except that the size is measured on the least diameter of the knot instead of on its width between lines parallel to the edges of the timber.

Increase to Ends.

(*d*) The size of knots on the narrow or horizontal faces and edges of wide or vertical faces of beams and stringers may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

Increase to Center.

(*e*) The size of knots on the wide or vertical faces of beams and stringers may increase proportionately from the size allowed at the edge to that allowed at the center line.

Posts and Timbers

Mean Diameter.

6. In posts and timbers, the measurement of a knot shall be made on the mean or average diameter.

7. MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT JOIST AND PLANK

(*a*) KNOTS ON WIDE FACES

WIDTH OF FACE, IN.	ON OR NEAR EDGE, MIDDLE THIRD OF LENGTH	CENTER LINE OF FACE
4	¾ in.	1¼ in.
6	1 "	2 "
8	1⅜ "	2⅝ "
10	1¾ "	3¼ "
12	2⅛ "	4 "
14	2⅜ "	4¼ "
16	2½ "	4⅝ "

(*b*) KNOTS ON NARROW FACES OF BOXED-HEART PIECES, MIDDLE THIRD OF LENGTH

THICKNESS OF PIECE, IN.	
2	$\frac{5}{8}$ in.
3	1 "
4	$1\frac{1}{4}$ "

(*c*) The sum of the diameters of all knots within the center half of the length of a beam shall not exceed one and one-half times the width of the face on which they occur.

8. MAXIMUM SIZE OF KNOTS IN COMMON JOIST AND PLANK

(*a*) KNOTS ON WIDE FACES

WIDTH OF FACE, IN.	ON OR NEAR EDGE, MIDDLE THIRD OF LENGTH	CENTER LINE OF FACE
4	1 in.	$1\frac{3}{4}$ in.
6	$1\frac{1}{2}$ "	$2\frac{1}{2}$ "
8	2 "	$3\frac{3}{8}$ "
10	$2\frac{1}{2}$ "	$4\frac{1}{4}$ "
12	3 "	$5\frac{1}{8}$ "
14	$3\frac{1}{4}$ "	$5\frac{5}{8}$ "
16	$3\frac{3}{8}$ "	6 "

(*b*) KNOTS ON NARROW FACES OF BOXED-HEART PIECES, MIDDLE THIRD OF LENGTH

THICKNESS OF PIECE, IN.	
2	$\frac{7}{8}$ in.
3	$1\frac{1}{4}$ "
4	$1\frac{3}{4}$ "

(*c*) The sum of the diameters of all knots within the center of the length of a joist or plank shall not exceed two times the width of face on which they occur.

9. (*a*) MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT BEAMS AND STRINGERS

WIDTH OF FACE, IN.	NARROW OR HORIZONTAL FACE, MIDDLE THIRD OF LENGTH	CENTER LINE OF WIDE OR VERTICAL FACE
5	$1\frac{1}{4}$ in.	..
6	$1\frac{1}{2}$ "	$1\frac{1}{2}$ in.
8	$1\frac{3}{4}$ "	2 "
10	2 "	$2\frac{1}{2}$ "
12	$2\frac{1}{8}$ "	3 "
14	$2\frac{1}{4}$ "	$3\frac{1}{4}$ "
16	$2\frac{3}{8}$ "	$3\frac{3}{8}$ "
18	..	$3\frac{5}{8}$ "
20	..	$3\frac{7}{8}$ "
22	..	4 "
24	..	$4\frac{1}{4}$ "

(*b*) The sum of the diameters of all knots within the center half of the length of a beam shall not exceed the width of the face on which they occur.

10. (*a*) MAXIMUM SIZE OF KNOTS IN COMMON BEAMS AND STRINGERS

WIDTH OF FACE, IN.	NARROW FACE OR HORIZONTAL FACE AND EDGE OF WIDE FACE, MIDDLE THIRD OF LENGTH	CENTER LINE OF WIDE FACE OR VERTICAL FACE
5	2 in.	..
6	$2\frac{3}{8}$ "	$2\frac{3}{8}$ in.
8	$2\frac{3}{4}$ "	$3\frac{1}{8}$ "
10	$3\frac{1}{8}$ "	4 "
12	$3\frac{3}{8}$ "	$4\frac{3}{4}$ "
14	$3\frac{5}{8}$ "	$5\frac{1}{8}$ "
16	$3\frac{7}{8}$ "	$5\frac{1}{2}$ "
18	..	$5\frac{7}{8}$ "
20	..	$6\frac{1}{8}$ "
22	..	$6\frac{1}{2}$ "
24	..	$6\frac{3}{4}$ "

(*b*) The sum of the diameters of all knots within the center half of the length of a post or timber shall not exceed one and one-half times the width of the face on which they occur.

11. (*a*) MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT POSTS AND TIMBERS

WIDTH OF FACE, IN.	KNOTS
6	$1\frac{1}{2}$ in.
8	2 "
10	$2\frac{1}{2}$ "
12	3 "
14	$3\frac{1}{4}$ "
16	$3\frac{3}{8}$ "
18	$3\frac{5}{8}$ "
20	$3\frac{7}{8}$ "
22	4 "
24	$4\frac{1}{4}$ "

(*b*) The sum of the diameters of all knots in any 6 in. of length shall not exceed twice the size of the maximum knot allowable.

12. (*a*) MAXIMUM SIZE OF KNOTS IN COMMON POSTS AND TIMBERS

WIDTH OF FACE, IN.	KNOTS
6	$2\frac{3}{8}$ in.
8	$3\frac{1}{8}$ "
10	4 "
12	$4\frac{3}{4}$ "
14	$5\frac{1}{8}$ "
16	$5\frac{1}{2}$ "

WIDTH OF FACE, IN.	KNOTS
18	5⅞ in.
20	6⅛ "
22	6½ "
24	6¾ "

(*b*) The sum of the diameters of all knots in any 6 in. of length shall not exceed twice the size of the maximum knot allowable.

13. MAXIMUM SHAKE AND CHECKS IN DENSE SELECT AND SELECT JOIST AND PLANK

WIDTH OF NARROW FACE, IN.	GREEN	SEASONED
2	½ in.	⅝ in.
3	¾ "	1 "
4	1 "	1¼ "

14. MAXIMUM SHAKE AND CHECKS IN COMMON JOIST AND PLANK

WIDTH OF NARROW FACE, IN.	GREEN	SEASONED
2	¾ in.	⅞ in.
3	1⅛ "	1¼ "
4	1½ "	1¾ "

15. MAXIMUM SHAKE AND CHECKS IN DENSE SELECT AND SELECT BEAMS AND STRINGERS

WIDTH OF FACE, IN.	GREEN	SEASONED
6	1½ in.	2 in.
8	2 "	2⅝ "
10	2½ "	3¼ "
12	3 "	4 "
14	3½ "	4⅝ "
16	4 "	5¼ "
18	4½ "	6 "
20	5 "	6⅝ "
22	5½ "	7¼ "
24	6 "	8 "

16. MAXIMUM SHAKE AND CHECKS IN COMMON BEAMS AND STRINGERS

WIDTH OF FACE, IN.	GREEN	SEASONED
5	2 in.	2⅛ in.
6	2⅜ "	2⅝ "
8	3⅛ "	3½ "
10	4 "	4⅜ "
12	5 "	5¼ "
14	5½ "	6⅛ "
16	6⅜ "	7 "
18	7⅛ "	8 "
20	8 "	8⅞ "
22	8¾ "	9¾ "
24	9½ "	10⅝ "

17. MAXIMUM SHAKE AND CHECKS IN DENSE SELECT AND SELECT POSTS AND TIMBERS

WIDTH OF FACE, IN.	GREEN	SEASONED
5	2 in.	2½ in.
6	2⅜ "	3 "
8	3⅛ "	4 "
10	4 "	5 "
12	4¾ "	6 "
14	5½ "	7 "
16	6⅜ "	8 "
18	7⅛ "	9 "
20	8 "	10 "
22	8¾ "	11 "
24	9½ "	12 "

18. MAXIMUM SHAKE AND CHECKS IN COMMON POSTS AND TIMBERS

WIDTH OF FACE, IN.	GREEN	SEASONED
6	3 in.	3½ in.
8	4 "	4¾ "
10	5 "	6 "
12	6 "	7⅛ "
14	7 "	8⅜ "
16	8 "	9½ "
18	9 "	10¾ "
20	10 "	12 "
22	11 "	13⅛ "
24	12 "	14⅜ "

SLOPE OF GRAIN

19*A*. DENSE SELECT AND SELECT JOIST AND PLANK:

Slope of grain in center half of length shall not exceed 1 in 12.

19*B*. COMMON JOIST AND PLANK:

Slope of grain in center half of length shall not exceed 1 in 10.

19*C*. DENSE SELECT AND SELECT BEAMS AND STRINGERS:

Slope of grain in center half of length shall not exceed 1 in 15.

19*D*. COMMON BEAMS AND STRINGERS:

Slope of grain in center half of length shall not exceed 1 in 10.

19*E*. DENSE SELECT AND SELECT POSTS AND TIMBERS:

Slope of grain shall not exceed 1 in 10.

19*F*. COMMON POSTS AND TIMBERS:

Slope of grain shall not exceed 1 in 8.

WANE AND SQUARE EDGES

WANE, DENSE SELECT AND SELECT GRADE

Wane One-Eighth. 20*A*. In the case of Dense Select and Select grade, wane is permitted, not exceeding one-eighth the width of any face.

WANE, COMMON GRADE

Wane One-Fourth. 20*B*. In the case of Common grade, wane is permitted, not exceeding one-fourth the width of any face.

SQUARE EDGES

Square. 20*C*. When "square-edge" is specified all edges must be square.

HEARTWOOD AND SAPWOOD

DURABILITY UNTREATED

Heartwood requirements shall be specified as required from the following:

HEARTWOOD PROVISIONS

Joist and Plank. 21*A*. Joist and plank shall have not less than 85 per cent of heart on the two faces, as measured across the faces anywhere in the length of the piece.

Beams and Stringers. 21*B*. Beams and stringers shall have not less than 85 per cent heart on each of the four faces measured across the faces anywhere in the length of the piece.

Timbers, 85 per cent. 21*C*. Timbers designated 85-per-cent shall have not less than 85 per cent heart on each of the four faces, measured across the face anywhere in the length of the piece.

Timbers, More Than 85 per cent. 21*D*. Timbers designated more than 85-per-cent shall have all heart on one face; the other face and two sides shall have not less than 85 per cent of heart, measured across the face or sides anywhere in the length of the piece

Timbers, Less Than 85 per cent. 21*E*. Timbers designated less than 85-per-cent shall have all heart on one face, the other face and two sides shall have not less than 75 per cent of heart, measured across the face or sides anywhere in the length of the piece.

FOR TREATMENT

Provision for sapwood for timber to be treated is covered by the following:

SAPWOOD PROVISIONS

Sapwood not Restricted. 22. There is no restriction as to sapwood for this material.

RATE OF GROWTH AND DENSITY

Select. Southern pine or Douglas fir of Select grade is to be selected for close grain.

Dense Select. Southern pine or Douglas fir of Dense Select grade is to be selected for density.

CLOSE GRAIN

Close Grain. 23. Douglas fir or southern pine shall be of close grain, averaging on either one end or the other not less than six nor more than twenty annual rings per inch measured over a 3-in. portion of a radial line located as described below and representative of the average growth on the cross-section. Pieces averaging from five to six annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

DENSITY

Dense. 24. Douglas fir or southern pine shall be dense, averaging on either one end or the other not less than six annual rings per inch and, in addition, one-third or more summerwood measured over a 3-in. portion of a radial line located as described below and representative of the average growth on the cross-section. The contrast in color between summerwood and springwood shall be distinct. Coarse-grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

CLOSE GRAIN OR DENSITY

Radial Line Not Representative. 25. When the radial line specified is not representative, it shall be shifted sufficiently to present a fair average, but the distance from the pith to the beginning of the 3-in. portion of the line in boxed heart pieces shall not be changed.

Two Radial Lines. 26. In case of disagreement in the measurement of close grain, two radial lines shall be chosen, and the number of rings shall be the average determined on these lines.

Average. 27. In case of disagreement in the measurement of density, two radial lines shall be chosen, and the number of rings and summerwood shall be the average determined on these lines.

LOCATION OF RADIAL LINE IN DOUGLAS FIR

Sidecut Pieces. 28. (*a*) In sidecut pieces of Douglas fir, the radial line shall be at a right angle to the annual rings and the center of the 3-in. portion of the line shall be at the center of the end of the piece.

Boxed-Heart Pieces.

(*b*) In boxed-heart pieces, the line shall run from the pith to the corner farthest from the pith. When the least dimension is 6 in. or less, the 3-in. portion of the line shall begin at a distance of one inch from the pith. When the least dimension is more than 6 in., the 3 in. portion of the line shall begin at a distance from the pith equal to 2 in. less than one-half the least dimension of the piece.

(*c*) If a 3-in. portion of the radial line cannot be obtained, the measurement shall be made over as much of the 3-in. portion as is available.

LOCATION OF RADIAL LINE IN SOUTHERN PINE

Boxed-Heart Pieces.

29. (*a*) In boxed-heart pieces of southern pine, the measurement shall be made over the third, fourth and fifth inches from the pith along the radial line.

No Pith.

(*b*) In cases where timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the inspection shall be made over 3 in. on an approximate radial line beginning at the edge nearest the pith in timbers over 3 in. in thickness and on the second inch nearest to the pith in timbers 3 in. or less in thickness.

Pith but Small Material, Large Material.

(*c*) In material containing the pith but not a 5-in. radial line, which is less than 2 by 8 in. in section or less than 8 in. in width, that does not show over 16 sq. in. on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-in. radial line, the inspection shall apply to the 3 in. farthest from the pith.

C. STRUCTURAL GRADES AND REFERENCE CODE

The individual specifications are divided into sections with general numbers for reference.

Where alternate requirements are listed, each has a capital letter added to the general number. For any material, appropriate choice must be made of such paragraphs.

Where several paragraphs occur under the general number and each is designated by a small letter, all such paragraphs must be used in preparing a complete specification.

In cases where only a small number of sizes are ordered it is permissible to shorten the tables of maximum defects by only copying sizes of defects corresponding with the sizes being ordered.

Three complete specifications are shown to illustrate the application of the code.

These are followed by a complete list of numbered specifications, brief description of material and appropriate code numbers of sections required to write a complete specification for this material.

TYPICAL SPECIFICATIONS FOR DENSE SELECT BEAMS AND STRINGERS (SOUTHERN PINE) WITH SQUARE EDGES AND HEARTWOOD REQUIREMENT FOR USE UNTREATED, ROUGH

SPECIFICATION REFERENCE NO. 1 IN SUB-DIVISION *D* ON CODED SPECIFICATIONS

I. SIZE REQUIREMENT

1*F*. Rough structural beams and stringers shall not be smaller than the nominal size less ¼ in. for sizes 7 in. and narrower and less ⅜ in. for sizes 8 in. and wider.

II. GRADE REQUIREMENTS

2. The material shall contain only sound wood.

GENERAL

3 (*a*) No pieces of exceptionally light weight shall be permitted except that light weight pieces otherwise of Select grade may be accepted in Common grade.

(*b*) Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the pieces. Checks and splits shall be limited as provided for shakes. No checks or combinations of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

(*c*) Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

(*d*) Cluster knots and knots in groups are not permitted.

(*e*) Knot holes and holes from other causes than knots shall be permitted as provided for knots.

(*f*) The size of a knot shall be measured on the section of the knot appearing on the surface under consideration.

(*g*) When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

(*h*) Knot sizes specified shall be applied to spike knots as well as to round knots.

(*i*) The mean average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

Beams and Stringers

5. (*a*) On the narrow or horizontal faces of beams and stringers the size of a knot shall be taken as its width between lines parallel to the edges of the timber.

(*b*) On the wide or vertical faces of beams and stringers the smallest diameter of a knot shall be taken as its size.

(*c*) Knots on the edges of wide or vertical faces of beams and stringers are limited to the same size as on the adjacent narrow or horizontal faces, except that the size is measured on the least diameter of the knot instead of on its width between lines parallel to the edges of the timber.

(*d*) The size of knots on the narrow or horizontal faces and edges of wide or vertical faces of beams and stringers may increase proportionately from the size allowed in the middle third to twice that size at the ends of the piece.

(*e*) The size of knots on the wide or vertical faces of beams and stringers may increase proportionately from the size allowed at the edge to that allowed at the center line.

9. (*a*) MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT BEAMS AND STRINGERS

WIDTH OF FACE, IN.	NARROW OR HORIZONTAL FACE, MIDDLE THIRD OF LENGTH	CENTER LINE OF WIDE OR VERTICAL FACE
5	1¼ in.	..
6	1½ "	1½ in.
8	1¾ "	2 "
10	2 "	2½ "
12	2⅛ "	3 "
14	2¼ "	3¼ "
16	2⅜ "	3⅜ "
18	..	3⅝ "
20	..	3⅞ "
22	..	4 "
24	..	4¼ "

(*b*) The sum of the diameters of all knots within the center half of the length of a beam shall not exceed the width of the face on which they occur.

15. MAXIMUM SHAKE AND CHECKS IN DENSE SELECT AND SELECT BEAMS AND STRINGERS

WIDTH OF FACE, IN.	GREEN	SEASONED
6	1½ in.	2 in.
8	2 "	2⅝ "
10	2½ "	3¼ "
12	3 "	4 "
14	3½ "	4⅝ "
16	4 "	5¼ "
18	4½ "	6 "
20	5 "	6⅝ "
22	5½ "	7¼ "
24	6 "	8 "

19*C*. Slope of grain in center half of length shall not exceed 1 in 15.

20*C*. All edges must be square.

21*B*. Beams and stringers shall have not less than 85 per cent heart on each of the four faces measured across the faces anywhere in the length of the piece.

24. Southern pine shall be dense, averaging on either one end or the other not less than six annual rings per inch and, in addition, one-third or more summerwood measured over a 3-in. portion of a radial line located as described below and representative of the average growth on the cross-section. The contrast in color between summerwood and spring wood shall be distinct. Coarse-grained material excluded by this rule shall be accepted as dense if averaging one-half or more summerwood.

25. When the radial line specified is not representative, it shall be shifted sufficiently to present a fair average but the distance from the pith to the beginning of the 3-in. portion of the line in boxed-heart pieces shall not be changed.

27. In case of disagreement, two radial lines shall be chosen, and the number of rings and summerwood shall be the average determined on these lines.

29(*a*) In boxed-heart pieces of southern pine, the measurement shall be made over the third, fourth and fifth inches from the pith along the radial line.

(*b*) In cases where the timbers do not contain the pith, and it is impossible to locate it with any degree of accuracy, the inspection shall be made over 3 in. on an approximate radial line beginning at the edge nearest the pith in timbers over 3 in. in thickness and on the second inch nearest to the pith in timbers 3 in. or less in thickness.

(*c*) In material containing the pith but not a 5-in. radial line, which is less than 2 by 8 in. in section or less than 8 in. in width, that does not show over 16 sq. in. on the cross-section, the inspection shall apply to the second inch from the pith. In larger material that does not show a 5-in. radial line, the inspection shall apply to the 3 in. farthest from the pith.

TYPICAL SPECIFICATION FOR SELECT POSTS AND TIMBERS (DOUGLAS FIR) WITH WANE PERMITTED AND SAPWOOD WANTED FOR TREATMENT, SURFACED FOUR SIDES

SPECIFICATION REFERENCE NO. 50 IN SUB-DIVISION *D* ON CODED SPECIFICATIONS

I. SIZE REQUIREMENT

1*C*. Structural beams, stringers, posts and timbers shall be when surfaced S1S, S1E, S2S, S4S not smaller than the nominal size less $\frac{3}{8}$ in. for sizes 7 in. and narrower and less $\frac{1}{2}$ in. for sizes 8 in. and wider.

II. GRADE REQUIREMENTS

2. The material shall contain only sound wood.

GENERAL

3(*a*) No pieces of exceptionally light weight shall be permitted, except that light weight pieces otherwise of Select grade may be accepted in Common grade.

(*b*) Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the piece. Checks and splits shall be limited as provided for shakes. No checks or combination of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

(*c*) Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

(*d*) Cluster knots and knots in groups are not permitted.

(*e*) Knot holes and holes from other causes than knots shall be permitted as provided for knots.

(*f*) The size of a knot shall be measured on the section of the knot appearing on the surface under consideration.

(*g*) When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

(*h*) Knot sizes specified shall be applied to spike knots as well as to round knots.

(*i*) The mean or average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

6. In posts and timbers, the measurement of a knot shall be made on the mean or average diameter.

11(*a*) MAXIMUM SIZE OF KNOTS IN DENSE SELECT AND SELECT POSTS AND TIMBERS

WIDTH OF FACE, IN.	KNOTS
6	1½ in.
8	2 "
10	2½ "
12	3 "
14	3¼ "
16	3⅜ "
18	3⅝ "
20	3⅞ "
22	4 "
24	4¼ "

(*b*) The sum of the diameters of all knots in any 6 in. of length shall not exceed twice the size of the maximum knot allowable.

17. MAXIMUM SHAKE AND CHECKS IN DENSE SELECT AND SELECT POSTS AND TIMBERS

WIDTH OF FACE, IN.	GREEN	SEASONED
5	2 in.	2½ in.
6	2⅜ "	3 "
8	3⅛ "	4 "
10	4 "	5 "
12	4¾ "	6 "
14	5½ "	7 "
16	6⅜ "	8 "
18	7⅛ "	9 "
20	8 "	10 "
22	8¾ "	11 "
24	9½ "	12 "

19*E*. The slope of the grain shall not exceed 1 in 10.

20*A*. Wane is permitted, not exceeding one-eighth the width of any face.

22. There is no restriction as to sapwood for this material.

23. Douglas fir shall be of close grain, averaging on either one end or the other not less than six nor more than twenty annual rings per inch measured

over a 3 in. portion of a radial line located as described below and representative of the average growth on the cross-section. Pieces averaging from five to six annual rings per inch shall be accepted as the equivalent of close grain if having one-third or more summerwood.

When the radial line is not representative, it shall be shifted sufficiently to present a fair average, but the distance from the pith to the beginning of the 3-in. portion of the line in boxed-heart pieces shall not be changed.

26. In case of disagreement, two radial lines shall be chosen, and the number of rings shall be the average determined on these lines.

28(*a*) In side-cut pieces of Douglas fir, the radial line shall be at a right angle to the annual rings and the center of the 3-in. portion of the line shall be at the center of the end of the piece.

(*b*) In boxed-heart pieces the line shall run from the pith to the corner farthest from the pith. When the least dimension is 6 in. or less, the 3-in. portion of the line shall begin at a distance of 1 in. from the pith. When the least dimension is more than 6 in. the 3-in. portion of the line shall begin at a distance from the pith equal to 2 in. less than one-half the least dimension of the piece.

(*c*) If a 3 in. portion of a radial line cannot be obtained, the measurement shall be made over as much of the 3 in. portion as is available.

TYPICAL SPECIFICATION FOR COMMON JOIST AND PLANK WITH WANE PERMISSIBILITY AND NO HEARTWOOD OR SAPWOOD REQUIREMENT, SURFACED S1S, S1E

SPECIFICATION REFERENCE NO. 38 IN SUB-DIVISION *D* ON CODED SPECIFICATIONS

I. SIZE REQUIREMENT

1.4. Standard structural joist and plank shall be, when surfaced S1S or S2S, not thinner than the nominal dimension less $\frac{3}{8}$ in. and when surfaced S1E or S2E not narrower than the nominal width less $\frac{3}{8}$ in. for sizes 2 to 7 in., inclusive, and less $\frac{1}{2}$ in. for sizes 8 in. and wider.

II. GRADE REQUIREMENTS

2. The material shall contain only sound wood.

GENERAL

3. (*a*) No pieces of exceptionally light weight shall be permitted, except that light-weight pieces otherwise of Select grade may be accepted in Common grade.

(*b*) Shake shall be measured on the ends of a piece, and its size shall be taken as the shortest distance between lines enclosing the shake and parallel to the wide faces of the piece. Checks and splits shall be limited as provided for shakes. No checks or combination of checks with shakes which would reduce the strength to a greater extent than the allowable shake shall be permitted.

(*c*) Where wane is permitted there shall be no combination of wane and knots which would reduce the strength more than the maximum allowable knot.

(*d*) Cluster knots and knots in groups are not permitted.

(*e*) Knot holes and holes from other causes than knots shall be permitted as provided for knots.

(*f*) The size of a knot shall be measured on the section of a knot appearing on the surface under consideration.

(*g*) When the mean or average diameter of a knot is specified, the size shall be taken as the average of the maximum and minimum diameters.

(*h*) Knot sizes specified shall be applied to spike knots as well as to round knots.

(*i*) The mean or average diameter of a spike knot shall be taken as the average of its length and its maximum width.

KNOTS

Joist and Plank

4. (*a*) On the wide faces of joist and plank, the measurement of a knot shall be made on the mean or average diameter.

(*b*) On the narrow faces of joist and plank, the size of a knot shall be taken as its width between lines parallel to the edges of the piece.

(*c*) The size of knots on the narrow faces and edges of wide faces of joist and plank may increase proportionately from the size allowed in the middle third to twice that size at the ends of the pieces.

(*d*) The size of knots on the wide faces of joist and plank may increase proportionately from the size allowed at the edge to that allowed at the center line.

8. (*a*) Maximum Size of Knots in Common Joist and Plank, Knots on Wide Faces

Width of Face, in.	On or Near Edge, Middle Third of Length	Center Line of Face
4	1 in.	1¾ in.
6	1½ "	2½ "
8	2 "	3⅜ "
10	2½ "	4¼ "
12	3 "	5⅛ "
14	3¼ "	5⅝ "
16	3⅜ "	6 "

(*b*) Knots on Narrow Faces of Boxed Heart Pieces, Middle Third of Length

Thickness of Piece, in.	Knots
2	⅞ in.
3	1¼ "
4	1¾ "

(*c*) The sum of diameters of all knots within the center half of the length of a joist or plank shall not exceed two times the width of face on which they occur.

14. MAXIMUM SHAKE AND CHECKS IN COMMON JOIST AND PLANK

WIDTH OF NARROW FACE, IN.	GREEN	SEASONED
2	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.
3	$1\frac{1}{8}$ "	$1\frac{1}{4}$ "
4	$1\frac{1}{2}$ "	$1\frac{3}{4}$ "

19*B*. The slope of the grain in the center half of the length shall not exceed 1 in 10.

20*B*. Wane is permitted, not exceeding one-fourth the width of any face.

D. CODED SPECIFICATIONS FOR STRUCTURAL GRADES

Beams and Stringers

No. 1. BEAMS AND STRINGERS, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 *(a+b+c+d+e+f+g+h+i)*, 5 *(a+b+c+d+e)*, 9 *(a+b)*, 15, 19*C*, 20*C*, 21*B*, 24, 25, 27, 28 *(a+b+c)* Douglas Fir or 29 *(a+b+c)* Southern Pine.

No. 2. BEAMS AND STRINGERS, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 *(a+b+c+d+e+f+g+h+i)*, 5 *(a+b+c+d+e)*, 9 *(a+b)*, 15, 19*C*, 20*C*, 24, 25, 27, 28 *(a+b+c)* Douglas Fir or 29 *(a+b+c)* Southern Pine.

No. 3. BEAMS AND STRINGERS, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, WANE PERMITTED:

1*C* (surfaced) or 1*F* (rough), 2, 3 *(a+b+c+d+e+f+g+h+i)*, 5 *(a+b+c+d+e)*, 9 *(a+b)*, 15, 19*C*, 20*A*, 24, 25, 27, 28 *(a+b+c)* Douglas Fir or 29 *(a+b+c)* Southern Pine.

No. 4. BEAMS AND STRINGERS, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, SAPWOOD WANTED FOR TREATMENT, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 *(a+b+c+d+e+f+g+h+i)*, 5 *(a+b+c+d+e)*, 9 *(a+b)*, 15,19*C*, 20*C*, 22, 24, 25, 27, 28 *(a+b+c)* Douglas Fir or 29 *(a+b+c)* Southern Pine.

No. 5. BEAMS AND STRINGERS, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, SAPWOOD WANTED FOR TREATMENT, WANE PERMITTED:

1*C* (surfaced) or 1*F* (rough), 2, 3 *(a+b+c+d+e+f+g+h+i)*, 5 *(a+b+c+d+e)*, 9 *(a+b)*, 15, 19*C*, 20*A*, 22, 24, 25, 27, 28 *(a+b+c)* Douglas Fir or 29 *(a+b+c)* Southern Pine.

No. 6. BEAMS AND STRINGERS, DOUGLAS FIR OR SOUTHERN PINE, SELECT, 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 *(a+b+c+d+e+f+g+h+i)*, 5 *(a+b+c+d+e)*, 9 *(a+b)*, 15, 19*C*, 20*C*, 21*B*, 23, 25, 26, 28 *(a+b+c)*, Douglas Fir or 29 *(a+b+c)* Southern Pine.

No. 7. BEAMS AND STRINGERS, DOUGLAS FIR OR SOUTHERN PINE, SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 *(a+b+c+d+e+f+g+h+i)*, 5 *(a+b+c+d+e)*, 9 *(a+b)*, 15, 19*C*, 20*C*, 23, 25, 26, 28 *(a+b+c)* Douglas Fir or 29 *(a+b+c)* Southern Pine.

No. 8. Beams and Stringers, Douglas Fir or Southern Pine, Select, no Heartwood or Sapwood Requirement, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*A*, 23, 25, 26, 28 (*a+b+c*) Douglas Fir or 29 (*a+b+c*) Southern Pine.

No. 9. Beams and Stringers, Douglas Fir or Southern Pine, Select, Sapwood Wanted for Treatment, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*C*, 22, 23, 25, 26, 28 (*a+b+c*) Douglas Fir or 29 (*a+b+c*) Southern Pine.

No. 10. Beams and Stringers, Douglas Fir or Southern Pine, Select, Sapwood Wanted for Treatment, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*A*, 22, 23, 25, 26, 28 (*a+b+c*) Douglas Fir or 29 (*a+b+c*) Southern Pine.

No. 11. Beams and Stringers, Select, 85 per cent Heartwood, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*C*, 21*B*.

No. 12. Beams and Stringers, Select, no Heartwood or Sapwood Requirement, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*C*.

No. 13. Beams and Stringers, Select, no Heartwood or Sapwood Requirement, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*A*.

No. 14. Beams and Stringers, Select, Sapwood Wanted for Treatment, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*C*, 22.

No. 15. Beams and Stringers, Select, Sapwood Wanted for Treatment, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 9 (*a+b*), 15, 19*C*, 20*A*, 22.

No. 16. Beams and Stringers, Common, 85 per cent Heartwood, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 10 (*a+b*), 16, 19*D*, 20*C*, 21*B*.

No. 17. Beams and Stringers, Common, no Heartwood or Sapwood Requirement, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 10 (*a+b*), 16, 19*D*, 20*C*.

No. 18. Beams and Stringers, Common, no Heartwood or Sapwood Requirement, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 10 (*a+b*), 16, 19*D*, 20*B*.

No. 19. Beams and Stringers, Common, Sapwood Wanted for Treatment, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 (*a+b+c+d+e+f+g+h+i*), 5 (*a+b+c+d+e*), 10 (*a+b*), 16, 19*D*, 20*C*, 22.

No. 20. BEAMS AND STRINGERS, COMMON, SAPWOOD WANTED FOR TREATMENT, WANE PERMITTED:

1*C* (surfaced) or 1*F* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 5 (*a*+*b*+*c*+*d*+*e*), 10 (*a*+*b*), 16, 19*D*, 20*B*, 22.

Joist and Plank

No. 21. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*C*, 21*A*, 24, 25, 27, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 22. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*C*, 24, 25, 27, 28 (*a*+*b*+*c*), Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 23. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, WANE PERMITTED:

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*A*, 24, 25, 27, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 24. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, SAPWOOD WANTED FOR TREATMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*C*, 22, 24, 25, 27, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 25. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, SAPWOOD WANTED FOR TREATMENT, WANE PERMITTED.

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*A*, 22, 24, 25, 27, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 26. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, SELECT, 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*C*, 21*A*, 23, 25, 26, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 27. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*C*, 23, 25, 26, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 28. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, WANE PERMITTED:

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*A*, 23, 25, 26, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 29. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, SELECT, SAPWOOD WANTED FOR TREATMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 4 (*a*+*b*+*c*+*d*), 7 (*a*+*b*+*c*), 13, 19*A*, 20*C*, 22, 23, 25, 26, 28, (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 30. JOIST AND PLANK, DOUGLAS FIR OR SOUTHERN PINE, SELECT, SAPWOOD WANTED FOR TREATMENT, WANE PERMITTED:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 7 $(a+b+c)$, 13, 19*A*, 20*A*, 22, 23, 25, 26, 28 $(a+b+c)$, Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 31. JOIST AND PLANK, SELECT, 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 7 $(a+b+c)$, 13, 19*A*, 20*C*, 21*A*.

No. 32. JOIST AND PLANK, SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 7 $(a+b+c)$, 13, 19*A*, 20*C*.

No. 33. JOIST AND PLANK, SELECT, NO HEARTWOOD OR SAPWOOD REQUIREMENT, WANE PERMITTED:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 7 $(a+b+c)$, 13, 19*A*, 20*A*.

No. 34. JOIST AND PLANK, SELECT, SAPWOOD WANTED FOR TREATMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 7 $(a+b+c)$, 13, 19*A*, 20*C*, 22.

No. 35. JOIST AND PLANK, SELECT, SAPWOOD WANTED FOR TREATMENT, WANE PERMITTED:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 7 $(a+b+c)$, 13, 19*A*, 20*A*, 22.

No. 36. JOIST AND PLANK, COMMON, 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 8 $(a+b+c)$, 14, 19*B*, 20*C*, 21*A*.

No. 37. JOIST AND PLANK, COMMON, NO HEARTWOOD OR SAPWOOD REQUIREMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 8 $(a+b+c)$, 14, 19*B*, 20*C*.

No. 38. JOIST AND PLANK, COMMON, NO HEARTWOOD OR SAPWOOD REQUIREMENT, WANE PERMITTED:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 8 $(a+b+c)$, 14, 19*B*, 20*B*.

No. 39. JOIST AND PLANK, COMMON, SAPWOOD WANTED FOR TREATMENT, SQUARE EDGES:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 9 $(a+b+c)$, 14, 19*B*, 20*C*, 22.

No. 40. JOIST AND PLANK, COMMON, SAPWOOD WANTED FOR TREATMENT, WANE PERMITTED:

1*A* (surfaced) or 1*D* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 4 $(a+b+c+d)$, 8 $(a+b+c)$, 14, 19*B*, 20*B*, 22.

Posts and Timbers

No. 41. POSTS AND TIMBERS, DOUGLAS FIR AND SOUTHERN PINE, DENSE SELECT, 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11, $(a+b)$, 17, 19*E*, 20*C*, 21*C*, 24, 25, 27, 28 $(a+b+c)$, Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 42. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, no Heartwood or Sapwood Requirement, Square Edges:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*, 24, 25, 27, 28 $(a+b+c)$, Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 43. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, no Heartwood or Sapwood Requirement, Wane Permitted:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*A*, 24, 25, 27, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 44. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, Sapwood Wanted for Treatment, Square Edges:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*, 22, 24, 25, 27, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 45. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, Sapwood Wanted for Treatment, Wane Permitted:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*A*, 22, 24, 25, 27, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 46. Posts and Timbers, Douglas Fir and Southern Pine, Select, 85 per cent Heartwood, Square Edges:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*, 21*C*, 23, 25, 26, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 47. Posts and Timbers, Douglas Fir and Southern Pine, Select, no Heartwood or Sapwood Requirement, Square Edges:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*, 23, 25, 26, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 48. Posts and Timbers, Douglas Fir and Southern Pine, Select, no Heartwood Requirement, Wane Permitted:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*A*, 23, 25, 26, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 49. Posts and Timbers, Douglas Fir and Southern Pine, Select, Sapwood Wanted for Treatment, Square Edges:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6 11 $(a+b)$, 17, 19*E*, 20*C*, 22, 23, 25, 26, 28 $(a+b+c)$, Douglas Fir, or 29 $(a+b+c)$ Southern Pine.

No. 50. Posts and Timbers, Douglas Fir and Southern Pine, Select, Sapwood Wanted for Treatment, Wane Permitted:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*A*, 22, 23, 25, 26, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 51. Posts and Timbers, Select, 85 per cent Heartwood, Square Edges:

1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*, 21*C*.

No. 52. Posts and Timbers, Select, no Heartwood or Sapwood Requirement, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*.

No. 53. Posts and Timbers, Select, no Heartwood or Sapwood Requirement, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*A*.

No. 54. Posts and Timbers, Select, Sapwood Wanted for Treatment, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*, 22.

No. 55. Posts and Timbers, Select, Sapwood Wanted for Treatment, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*A*, 22.

No. 56. Posts and Timbers, Common, 85 per cent Heartwood, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 12 $(a+b)$, 18, 19*F*, 20*C*, 21*C*.

No. 57. Posts and Timbers, Common, no Heartwood or Sapwood Requirement, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 12 $(a+b)$, 18, 19*F*, 20*C*.

No. 58. Posts and Timbers, Common, no Heartwood or Sapwood Requirement, Wane Permitted:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 12 $(a+b)$, 18, 19*F*, 20*B*.

No. 59. Posts and Timbers, Common, Sapwood Wanted for Treatment, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 12 $(a+b)$ 18, 19*F*, 20*C*, 22.

No. 60. Posts and Timbers, Common, Sapwood Wanted for Treatment, Wane Permitted.
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 12 $(a+b)$, 18, 19*F*, 20*B*, 22.

No. 61. Posts and Timbers, Douglas Fir and Southern Pine, Dense Select, One Face all Heartwood and Remaining Face and Sides 85 per cent Heartwood, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$, 17, 19*E*, 20*C*, 21*D*, 24, 25, 27, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 62. Posts and Timbers, Douglas Fir or Southern Pine, Select, One Face all Heartwood and Remaining Face and Sides 85 per cent Heartwood, Square Edges:
1*C* (surfaced) or 1*F* (rough), 2, 3 $(a+b+c+d+e+f+g+h+i)$, 6, 11 $(a+b)$ 17, 19*E*, 20*C*, 21*D*, 23, 25, 26, 28 $(a+b+c)$ Douglas Fir or 29 $(a+b+c)$ Southern Pine.

No. 63. Posts and Timbers, Select, one Face all Heartwood and Remaining Face and Sides 85 per cent Heartwood, Square Edges:

1*C* (surfaced) or 1*F* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 6, 11 (*a*+*b*), 17, 19*E*, 20*C*, 21*D*.

No. 64. POSTS AND TIMBERS, COMMON, ONE FACE ALL HEARTWOOD AND REMAINING FACE AND SIDES 85 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 6, 12 (*a*+*b*), 18, 19*F*, 20*C*, 21*D*.

No. 65. POSTS AND TIMBERS, DOUGLAS FIR OR SOUTHERN PINE, DENSE SELECT, ONE FACE ALL HEARTWOOD AND REMAINING FACE AND SIDES 75 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 6, 11 (*a*+*b*), 17, 19*E*, 20*C*, 21*E*, 24, 25, 27, 28 (*a*+*b*+*c*), Douglas Fir, or 29 (*a*+*b*+*c*) Southern Pine.

No. 66. POSTS AND TIMBERS, DOUGLAS FIR OR SOUTHERN PINE, SELECT, ONE FACE ALL HEARTWOOD AND REMAINING FACE AND SIDES 75 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 6, 11 (*a*+*b*), 17, 19*E*, 20*C*, 21*E*, 23, 25, 26, 28 (*a*+*b*+*c*) Douglas Fir or 29 (*a*+*b*+*c*) Southern Pine.

No. 67. POSTS AND TIMBERS, SELECT, ONE FACE ALL HEARTWOOD AND REMAINING FACE AND SIDES 75 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 6, 11 (*a*+*b*), 17, 19*E*, 20*C*, 21*E*.

No. 68. POSTS AND TIMBERS, COMMON, ONE FACE ALL HEARTWOOD AND REMAINING FACE AND SIDES 75 PER CENT HEARTWOOD, SQUARE EDGES:

1*C* (surfaced) or 1*F* (rough), 2, 3 (*a*+*b*+*c*+*d*+*e*+*f*+*g*+*h*+*i*), 6, 12 (*a*+*b*), 18, 19*F*, 20*C*, 21*E*.

INDEX TO NUMBERS OF SPECIFICATIONS

Grades	Additional Requirements						
	For Use Untreated					For Treating	
	For Durability Heartwood Required			No Heartwood or Sapwood Required		Sapwood not Restricted	
	One Face 100 per cent; Other Three Faces 85 per cent	All Faces 85 per cent	One Face 100 per cent; Other Three Faces 75 per cent				
	Square Edge			Square Edge	Wane Permitted	Square Edge	Wane Permitted
BEAMS AND STRINGERS							
Dense Select							
Douglas Fir or Southern Pine	..	1	..	2	3	4	5
Select							
Douglas Fir or Southern Pine	..	6	..	7	8	9	10
Select							
Any other softwood	..	11	..	12	13	14	15
Common							
Any softwood	..	16	..	17	18	19	20
JOIST AND PLANKS							
Dense Select							
Douglas Fir or Southern Pine	..	21	..	22	23	24	25
Select							
Douglas Fir or Southern Pine	..	26	..	27	28	29	30
Select							
Any other softwood	..	31	..	32	33	34	35
Common							
Any softwood	..	36	..	37	38	39	40
POST AND TIMBERS							
Dense Select							
Douglas Fir or Southern Pine	61	41	65	42	43	44	45
Select							
Douglas Fir or Southern Pine	62	46	66	47	48	49	50
Select							
Any other softwood	63	51	67	52	53	54	55
Common							
Any softwood	64	56	68	57	58	59	60

APPENDIX[1]

WORKING STRESSES

NOTES ON TABLES OF WORKING STRESSES

Authority.

1. The working stresses in the accompanying Table I are recommended by the Forest Products Laboratory, U. S. Forest Service, for structural grades complying with Basic Provisions for Structural Material of American Lumber Standards, including, also, stresses for red and white oak, as the same structural grades can be applied to hardwoods as to soft. In beam and stringer, and post and timber grades, stresses are given only for the species commonly cut to those sizes. Stresses for any other species can be obtained from the Forest Products Laboratory.

Minimum Strength Value.

2. Structural grades are developed to insure minimum strength values. The defects permitted in the Common grades provide material having not less than 60 per cent of the strength of green clear wood, and in the Select grades, of 75 per cent, although in Douglas fir and southern pine the stresses recommended in compression and in extreme fiber in bending are 80 per cent of green clear wood strength on account of the limitation on rate of growth.

Elastic Limit Versus Breaking Strength.

3. In determining working stresses, the Forest Products Laboratory has considered both elastic limit and breaking strength. Elastic limit, however, is more variable and less definite than ultimate strength, and the latter is taken as the more dependable basis for the determination of safe working stresses.

Factor of Safety.

4. The factor of safety at a given working stress varies materially with the duration of the stress. At the recommended working stresses, given in the table for continuously dry locations, the average timber in buildings has a factor of safety of 6 on impact loading,[2] a factor of 4 for five-minute loads and $2\frac{1}{4}$ for long-time loading, with a minimum factor of safety of 2 on 75 per cent of the pieces under long-time loading. About one piece in 100, of very light weight and with maximum defects for the grade, would be expected to break at $1\frac{1}{2}$ times the recommended stress under loading of approximately 10 years duration. For new timbers in bridge construction, the factors of safety are about 15 per cent greater.

Basis of Working Strength.

5. Working stresses are based on the strength of the clear wood of the various species and, in some properties, on grade as fixed by limitation on size and location of knots, extent of shake and checks, and extent of cross grain, on conditions of exposure during use, and on size of piece. In southern pine and Douglas fir working stresses in some properties are increased for rate of growth and percentage of summerwood.

Variations, Exposure, Grade, Size.

6. Working stresses for extreme fiber in bending are varied with grade, extent of exposure, and size of piece; in horizontal shear, they are varied with grade; in compression parallel to grain, with grade and exposure; in compression perpendicular to grain, with exposure.

7. Working stresses in shear are not varied with size or extent of exposure; in compression parallel to grain they are not varied with size; in compression

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[1] Published as information only.

[2] If impact stresses are neglected when less than 100 per cent of the live load producing them, the factor of safety for such loads would be reduced from 6 to a minimum of 3.

perpendicular to grain they are not varied with grade or size; in modulus of elasticity they are taken as the same in all grades.

Rate of Growth and Density. 8. In southern pine and Douglas fir, working stresses for extreme fiber in bending, compression parallel to grain and compression perpendicular to grain are increased for rate of growth and percentage of summerwood requirements. Values in these species in shear are increased for summerwood requirements but not for limitation on rate of growth. Modulus of elasticity is not varied with these properties.

Variations in Working Stresses. 9. The several permitted working stresses vary with conditions as follows, a √ indicating that the stress varies:

PROPERTY	GOVERNING DEFECTS	CONDITIONS OF EXPOSURE	GRADE	SIZE OF PIECE	RATE OF GROWTH	DENSITY
Extreme fiber stress in bending	Knots and Angle of Grain	√	√	√[a]	√	√
Horizontal shear	Shake and Checks	..	√	..	..	√
Compression parallel to Grain	Knots and Angle of Grain	√	√	..	√	√
Compression Perpendicular to Grain		√	..	..	√	√
Modulus of Elasticity		..	..	..	..	..

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[a] Dry location only.

Exposure. 10. Working values are given for three conditions of exposure during use: (a) Continuously dry, (b) Occasionally wet but quickly dried, (c) More or less continuously damp or wet. Judgment should be exercised as to the values to be used in a particular case.

(*a*) *Continuously Dry.*—Continuously dry contemplates use in interior or protected construction not subject to conditions of excessive dampness or high humidity.

(*b*) *Occasionally Wet.*—Occasionally wet but quickly dried assumes use in such exterior structures as bridges, trestles, grandstands or bleachers, and exposed frame work of open sheds.

(*c*) *Continuously Wet.*—More or less continuously damp or wet would apply to material exposed to waves or tidewater, or in contact with earth, or used in a building in portions that would be more or less continuously wet.

Impact. 11. The working values recommended may be used without allowance for impact up to 100 per cent. Shear stresses for details may be taken as 50 per cent greater than the values for horizontal shear given in the table.

Analysis for Shear Stress. 12. Recognition of all loads in designing for moving loads, or loads concentrated near a support, gives an assumed shearing stress higher than is actually developed. In calculating the shear at one end of a beam, the concentrated loads between this end and a point distant three times the depth of the beam from the support may be considered as acting at this point. In moving loads, as on highway bridges or railway stringers, in computing the shear at one end it is safe to ignore all wheel loads between this support and a point three times the depth of the beam or stringer from this point when the balance of the span is assumed loaded so as to give a maximum shear stress.

Permanent Set. 13. Timber constantly yields under long continued loading, acquiring a permanent set. This set with a fully loaded beam is about equal to the deflec-

TABLE I.—DESIGNING STRESSES

(Pounds per square inch)

Developed by Forest Products Laboratory, United States Forest Service

JOIST AND PLANK (4 IN. AND LESS IN THICKNESS)

SELECT GRADE

Species	Varied with Conditions of Exposure to Moisture						Not Varied with Conditions of Exposure	
	Continuously Dry		Occasionally Wet, but Quickly Dried		More or Less Continuously Damp or Wet		Horizontal Shear	Modulus of Elasticity
	Extreme Fiber Stress in Bending	Compression Perpendicular to Grain	Extreme Fiber Stress in Bending	Compression Perpendicular to Grain	Extreme Fiber Stress in Bending	Compression Perpendicular to Grain		
Cedar: western red	900	200	710	150	670	125	80	1 000 000
northern and southern white	750	175	580	140	535	100	70	800 000
Port Orford	1100	250	890	200	800	150	90	1 200 000
Alaska	1100	250	890	200	800	150	85	1 200 000
Cypress: southern	1300	350	980	250	800	225	100	1 200 000
Douglas Fir:								
Coast Region: Select	1600	345	1235	240	950	215	90	1 600 000
Dense Select	1750	380	1350	265	1040	235	100	1 600 000
Rocky Mountain Region	1100	275	800	225	625	200	85	1 200 000
Fir: balsam	900	150	670	125	535	100	70	1 000 000
Golden, noble, silver, white	1100	300	800	225	710	200	70	1 100 000
Hemlock: West Coast	1300	300	980	225	800	200	75	1 400 000
Eastern	1100	300	800	225	710	200	70	1 100 000
Larch: western	1200	325	980	225	800	200	100	1 300 000
Oak: red and white	1400	500	1070	375	890	300	125	1 500 000
Pine: southern: Select	1600	345	1235	240	950	215	110	1 600 000
Dense Select	1750	380	1350	265	1040	235	120	1 600 000
California, Idaho and Northern white, Pondosa and sugar	900	250	710	150	670	125	85	1 000 000
Norway	1100	300	890	175	710	150	85	1 200 000
Redwood	1200	250	890	150	710	125	70	1 200 000
Spruce: red, white, Sitka	1100	250	800	150	710	125	85	1 200 000
Engelmann	750	175	580	140	445	100	70	800 000
Tamarack: eastern	1200	300	980	225	800	200	95	1 300 000

COMMON GRADE

Cedar: western red	720	200	600	150	565	125	64	1 000 000
northern and southern white	600	175	490	140	450	100	56	800 000
Port Orford	880	250	750	200	675	150	72	1 200 000
Alaska	880	250	675	200	600	150	68	1 200 000
Cypress: southern	1040	350	825	250	675	225	80	1 200 000
Douglas Fir:								
Coast region	1200	325	980	225	750	200	72	1 600 000
Rocky Mountain region	880	275	675	225	525	200	68	1 200 000
Fir: balsam	720	150	565	125	450	100	56	1 000 000
Golden, noble, silver, white	880	300	675	225	600	200	56	1 100 000
Hemlock: West Coast	1040	300	825	225	675	200	60	1 400 000
Eastern	880	300	675	225	600	200	56	1 100 000
Larch: western	960	325	825	225	675	200	80	1 300 000
Oak: red and white	1120	500	900	375	750	300	100	1 500 000
Pine: southern	1200	325	980	225	750	200	88	1 600 000
California, Idaho and northern white Pondosa and sugar	720	250	600	150	565	125	68	1 000 000
Norway	880	300	750	175	600	150	68	1 200 000
Redwood	960	250	750	150	600	125	56	1 200 000
Spruce: red, white, Sitka	880	250	675	150	600	125	68	1 200 000
Engelmann	600	175	490	140	375	100	56	800 000
Tamarack: eastern	960	300	825	225	675	200	76	1 300 000

tion using the modulus of elasticity as given in the tables. In order to minimize the results of sag, it is advisable to use values one-half those given in the tables.

Compression in Short Columns.

14. The working stresses for compression parallel to grain are for use on posts, struts, etc., with unsupported length not greater than eleven times their least dimension. They are also for use in end bearing on compression members, as a short column or strut is more likely to fail at the end than at any other point in its length, and the variations in moisture content are greater there.

TABLE I.—DESIGNING STRESSES (*Continued*)

BEAMS AND STRINGERS (5 IN. AND THICKER)

SELECT GRADE

Species	Varied with Conditions of Exposure to Moisture						Not Varied with Conditions of Exposure	
	Continuously Dry		Occasionally Wet, but Quickly Dried		More or Less Continuously Damp or Wet			
	Extreme Fiber Stress in Bending	Compression Perpendicular to Grain	Extreme Fiber Stress in Bending	Compression Perpendicular to Grain	Extreme Fiber Stress in Bending	Compression Perpendicular to Grain	Horizontal Shear	Modulus of Elasticity
CEDAR: western red	900	200	800	150	750	125	80	1 000 000
Port Orford	1100	250	1000	200	900	150	90	1 200 000
DOUGLAS FIR:								
Coast region: Select	1600	345	1385	240	1065	215	90	1 600 000
Dense Select	1750	380	1515	265	1165	235	100	1 600 000
Rocky Mountain region	1100	275	900	225	700	200	85	1 200 000
HEMLOCK: West Coast	1300	300	1100	225	900	200	75	1 400 000
LARCH: western	1200	325	1100	225	900	200	100	1 300 000
OAK: red and white	1400	500	1200	375	1000	300	125	1 500 000
PINE: southern: Select	1600	345	1385	240	1065	215	110	1 600 000
Dense Select	1750	380	1515	265	1165	235	120	1 600 000
REDWOOD	1200	250	1000	150	800	125	70	1 200 000
SPRUCE: red, white, Sitka	1100	250	900	150	800	125	85	1 200 000
COMMON GRADE								
CEDAR: western	720	200	640	150	600	125	64	1 000 000
Port Orford	880	250	800	200	720	150	72	1 200 000
DOUGLAS FIR:								
Coast region	1200	325	1040	225	800	200	72	1 600 000
Rocky Mountain region	880	275	720	225	560	200	68	1 200 000
HEMLOCK: West Coast	1040	300	880	225	720	200	60	1 400 000
LARCH: western	960	325	880	225	720	200	80	1 300 000
OAK: red and white	1120	500	960	375	800	300	100	1 500 000
PINE: southern	1200	325	1040	225	800	200	88	1 600 000
REDWOOD	960	250	800	150	640	125	56	1 200 000
SPRUCE: red, white, Sitka	880	250	720	150	640	125	68	1 200 000

Compression in Medium-Length Columns.

15. For columns of intermediate length, the Forest Products Laboratory finds from tests recently made that a fourth-power parabola, tangent to the Euler curve, is a conservative representation of the law controlling the strength. That is, from the short block to the long column in which the strength is dependent in stiffness, there is a falling off in ultimate strength which follows a smooth curve, very flat at first but curving sharply to become tangent to the Euler curve at two-thirds of the ultimate crushing strength.

Formula.

16. For columns from $\frac{l}{d} = 11$ until $\frac{P}{A} = \frac{2S}{3}$.

$$\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$$

where P = total load in pounds;

A = area in square inches;

$\frac{P}{A}$ = unit compressive stress;

S = safe stress in compression parallel to grain;

l = unsupported length in inches;

d = least dimension in inches;

K = a constant dependent on the modulus of elasticity and compressive strength parallel to grain.

TABLE I.—DESIGNING STRESSES (*Continued*).

POSTS AND TIMBERS (6 BY 6 IN. AND LARGER)

SELECT GRADE

Species	Varied with Conditions of Exposure to Moisture						Not Varied with Conditions of Exposure
	Continuously Dry		Occasionally Wet, but Quickly Dried		More or Less Continuously Damp or Wet		Modulus of Elasticity
	Compression Parallel to Grain	Compression Perpendicular to Grain	Compression Parallel to Grain	Compression Perpendicular to Grain	Compression Parallel to Grain	Compression Perpendicular to Grain	
CEDAR: western red	700	200	700	150	650	125	1 000 000
Port Orford	900	250	825	200	750	150	1 200 000
DOUGLAS FIR:							
Coast region: Select	1175	345	1065	240	905	215	1 600 000
Dense Select	1285	380	1165	265	990	235	1 600 000
Rocky Mountain region	800	275	800	225	700	200	1 200 000
HEMLOCK: West Coast	900	300	900	225	800	200	1 400 000
LARCH: western	1100	325	1000	225	800	200	1 300 000
OAK: red and white	1000	500	900	375	800	300	1 500 000
PINE: southern: Select	1175	345	1065	240	905	215	1 600 000
Dense Select	1285	380	1165	265	990	235	1 600 000
REDWOOD	1000	250	900	150	750	125	1 200 000
SPRUCE: red, white, Sitka	800	250	750	150	650	125	1 200 000
COMMON GRADE							
CEDAR: western red	560	200	560	150	520	125	1 000 000
Port Orford	720	250	660	200	600	150	1 200 000
DOUGLAS FIR: Coast region	880	325	800	225	680	200	1 600 000
Rocky Mountain region	640	275	640	225	560	200	1 200 000
HEMLOCK: West Coast	720	300	720	225	640	200	1 400 000
LARCH: western	880	325	800	225	640	200	1 300 000
OAK: red and white	800	500	720	375	640	300	1 500 000
PINE: southern	880	325	800	225	680	200	1 600 000
REDWOOD	800	250	720	150	600	125	1 200 000
SPRUCE: red, white, Sitka	640	250	600	150	520	125	1 200 000

Influence of Defects.

17. The influence of defects on the compressive strength of columns of constant cross-section decreases as the length increases. When $\frac{l}{d}$ equals the value of K for the species and grade, defects such as are allowable in the grade have little influence on the strength as a column. Beyond this length the investigation of the strength of columns indicated that the Euler formula is quite accurate for long wooden columns with pin-end connections and that the maximum load is dependent upon stiffness. In such columns, a factor of safety of 3 should be applied to values of modulus of elasticity in order to obtain safe loading.

The laboratory does not, with the present data and under ordinary conditions, find justification for increasing the stresses on square-end columns over those for carefully centered pin-end columns. Tests to determine the influence of end conditions are still being made and it is probable that under special conditions higher stresses can be used.

Long Columns.

18. For long columns, with factor of safety of 3 $= \frac{P}{A} = \frac{4E}{15\left(\frac{l}{d}\right)^2}$

where E = Modulus of elasticity and the other notation is as above.

Maximum Length.

19. Columns should be limited in slenderness to $\frac{l}{d} = 50$.

Direct Tension.

20. For direct tension, the same values as for extreme fiber stress in bending may be used. Straight grained wood has greater resistance to tension than to any other kind of stress. It has been found practically impossible, however, to design joints that will develop anywhere near the full tensile strength.

Joists and Beams in Direct Tension.

21. Grades of joists of beams may be used for members in direct tension, as in bottom chords of trusses, increase in size of defects towards ends being permissible because of the gradual application of stresses through splice plates or end connections.

Joist and Plank, Vertical or Horizontal.

22. The provisions of the joist and plank grades are such that working stresses for these grades may be applied to material used with wide faces vertical or horizontal.

Working Stresses in Timbers Nearly Square.

23. Where working stresses in bending are required for caps, bridge ties, etc., they should be graded on beam and stringer grades, but as such material is often square or has horizontal faces wider than the vertical faces, in contrast to beams and stringers in which the narrow faces are horizontal faces and the wide faces are vertical, care should be exercised that the knot limitations are applied to the proper faces.

Two-Span Stringers.

24. In railway stringers of two spans length, defects throughout the center two-thirds should be limited as in the center third of single span stringer, for the maximum moment will be over the center support and although the full positive moment would not be developed in either span as long as there was resistance to negative moment over the center support, there might be circumstances in which full positive moment of resistance at the centers of the two spans would be desirable.

SAFE LOADS FOR WOODEN COLUMNS

The unit working stresses in compression parallel to grain for columns whose ratio of unsupported length to least dimension does not exceed 11 should be not greater than that given for the species in the accompanying Table I on Designing Stresses.

For columns, the ratio of whose unsupported length to least dimension is greater than 11, the following formula may be used until the reduction in allowable stress equals one-third the stress for short columns:

$$\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$$

when $\frac{P}{A}$ = unit compressive stress;

S = safe stress in compression parallel to grain;

l = unsupported length in inches;

d = least dimension in inches;

K = a constant dependent on the modulus of elasticity and the compressive strength parallel to grain.

For columns of greater length, the Euler formula given below, which includes factor of safety of three, shall be used:

$$\frac{P}{A} = \frac{4E}{15\left(\frac{l}{d}\right)^2}$$

where E = modulus of elasticity, and the other notation are as given above.

Columns shall be limited in slenderness to $\frac{l}{d} = 50$.

VALUES OF "K" FOR COLUMNS OF INTERMEDIATE LENGTH

SPECIES	GRADE	
	Select	Common
Cedar, Alaska	25	28
Cedar, western red	24	27
Cedar, northern and southern white	25	27
Cedar, Port Orford	23	26
Cypress, bald	21	24
Douglas fir (western Washington and Oregon)	24	27
Douglas fir (Rocky Mountain type)	25	28
Fir, balsam	24	27
Fir, commercial white	25	28
Hemlock, western	25	28
Hemlock, eastern	25	28
Larch, western	22	25
Pine, southern yellow	24	27
Pine, white, sugar, western white, western yellow	23	26
Pine, Norway	25	28
Redwood	22	25
Spruce, red, white, Sitka	25	28
Spruce, Engelmann	23	26
Tamarack, eastern	23	26

STRENGTH OF COLUMNS OF INTERMEDIATE LENGTH, EXPRESSED AS A PERCENTAGE OF STRENGTH OF SHORT COLUMNS

Values for the expression $\left[1 - \frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$ in the formula: $\frac{P}{A} = S\left[1 - \frac{1}{3}\left(\frac{l}{Kd}\right)^4\right]$

	RATIO OF LENGTH TO LEAST DIMENSION IN RECTANGULAR TIMBERS																	
K	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
21	96	95	93	91	89	86	82	78	73	67	..	..	..	..	..	..	..	..
22	97	96	95	93	91	88	85	81	77	72	67	..	..	..	..	..	..	..
23	98	97	95	94	92	90	87	84	81	77	72	67	..	..	..	..	..	..
24	98	97	96	95	93	92	89	87	84	80	76	72	67	..	..	..	..	..
25	98	98	97	96	94	93	91	89	86	83	80	76	72	67	..	..	..	..
26	99	98	97	96	95	93	92	91	89	86	83	80	76	72	67	..	..	..
27	99	98	98	97	96	95	93	92	90	88	85	82	79	74	71	67	..	..
28	99	98	98	97	96	95	94	93	91	89	87	85	82	79	75	71	67	..
29	99	99	98	98	97	96	95	94	92	91	89	87	84	82	79	75	71	67

NOTE.—This table can also be used for columns not rectangular, the l/d being equivalent to 0.289 l/r, where r is the least radius of gyration of the section.

TENTATIVE METHOD OF TEST
FOR
DISTILLATION OF CREOSOTE OIL[1]

Serial Designation: D 246 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. This method of test is suitable for all types and grades of creosote and mixtures of creosote with tars and oils used for timber preservation.

I. APPARATUS

Flask. 2. *Flask.*—The distillation flask, Fig. 1, shall be a side neck distilling flask, having the following dimensions:

Diameter of bulb (outside)	86 mm.	±1.5 mm.
Diameter of neck (inside)	22 "	±1.0 "
Diameter of tubulature (inside)	10 "	±0.5 "
Length of neck	43 "	±1 "
Distance, top of neck to tubulature	25 "	±1 "
Angle of tubulature	73 deg.	±1 deg.
Length of tubulature	22 cm.	±0.5 cm.

Condenser Tubes. 3. *Condenser Tube.*—The condenser tube shall be a suitable form of tapered glass tubing of the following dimensions:

Diameter of small end	12.5 mm.	permissible variation	±1.5 mm.
Diameter of large end	28.5 "	permissible variation	±3.0 "
Length	360.0 "	permissible variation	±4.0 "

Shield. 4. *Shield.*—An asbestos shield of the form and approximate dimensions shown in Fig. 2 shall be used to protect the retort from air currents and to prevent radiation. This may be covered with galvanized iron, as such an arrangement is more convenient and more permanent.

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[1] Criticisms of this Tentative Method are solicited, and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

This Tentative Method of Test is intended to replace the present Method of Test for Distillation appearing as Sections 10 to 12 of the Standard Methods of Sampling and Analysis of Creosote Oil (D 38 - 18), 1924 Book of A.S.T.M. Standards.

Receivers. 5. *Receivers.*—The distillates shall be collected in tared Erlenmeyer flasks having a capacity of 100 ml.

Thermometer. 6. *Thermometer.*—The thermometer shall conform to the following requirements. These specifications cover a total immersion thermometer graduated in either Centigrade or Fahrenheit degrees as specified, the range being from 0 to 400° C. or 30 to 760° F., respectively.

TYPE: Etched stem, glass.

LIQUID: Mercury.

RANGE AND SUBDIVISION: 0 to 400° C. in 1° C. or 30 to 760° F. in 2° F.

TOTAL LENGTH: 378 to 384 mm. (14.88 to 15.12 in.).

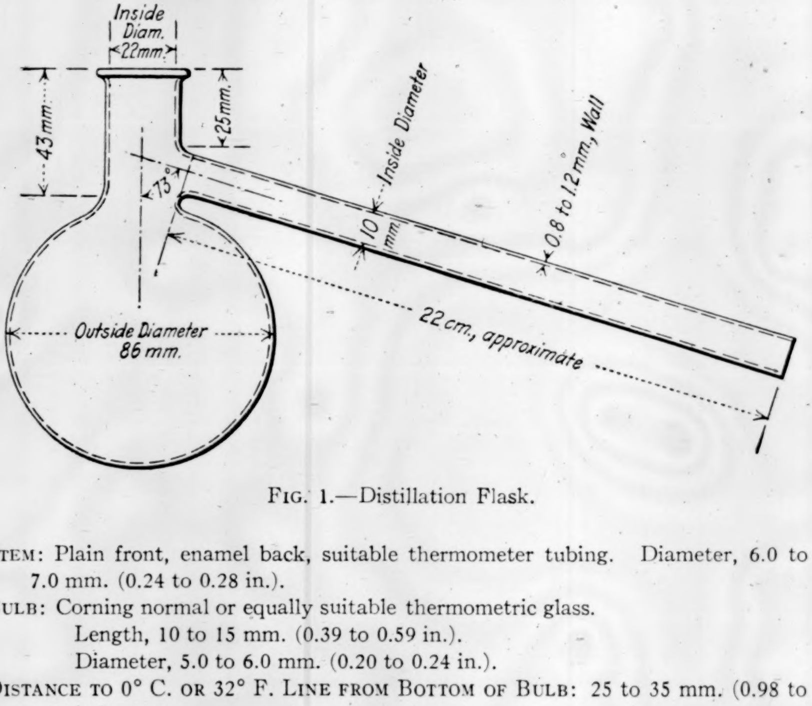

FIG. 1.—Distillation Flask.

STEM: Plain front, enamel back, suitable thermometer tubing. Diameter, 6.0 to 7.0 mm. (0.24 to 0.28 in.).

BULB: Corning normal or equally suitable thermometric glass.
Length, 10 to 15 mm. (0.39 to 0.59 in.).
Diameter, 5.0 to 6.0 mm. (0.20 to 0.24 in.).

DISTANCE TO 0° C. OR 32° F. LINE FROM BOTTOM OF BULB: 25 to 35 mm. (0.98 to 1.38 in.).

DISTANCE TO 400° C. OR 752° F. LINE FROM TOP OF THERMOMETER: 30 to 45 mm. (1.18 to 1.77 in.).

FILLING ABOVE MERCURY: Nitrogen gas.

TOP FINISH: Glass ring.

GRADUATION: All lines, figures, and letters clear cut and distinct. The first and each succeeding 5° C. or 10° F. line to be longer than the remaining lines. Graduations to be numbered at each multiple of 10° C. or 20° F.

IMMERSION: Total.

SPECIAL MARKING: "A.S.T.M. High Distillation," a serial number and the manufacturer's name or trade mark shall be etched on the stem.

SCALE ERROR: The error at any point of the scale up to 370° C. or 700° F. when the thermometer is standardized as provided below shall not exceed 1° C. or 2° F.

STANDARDIZATION: The thermometer shall be standardized immersed in the testing bath to the top of the mercury column, at the ice point and at temperature intervals of approximately 50° C. or 100° F. up to 370° C. or 700° F.

TEST FOR PERMANENCY OF RANGE: After being subjected to a temperature between 360 and 370° C. or 680 and 700° F. for 24 hours, the accuracy shall be within the limit specified.

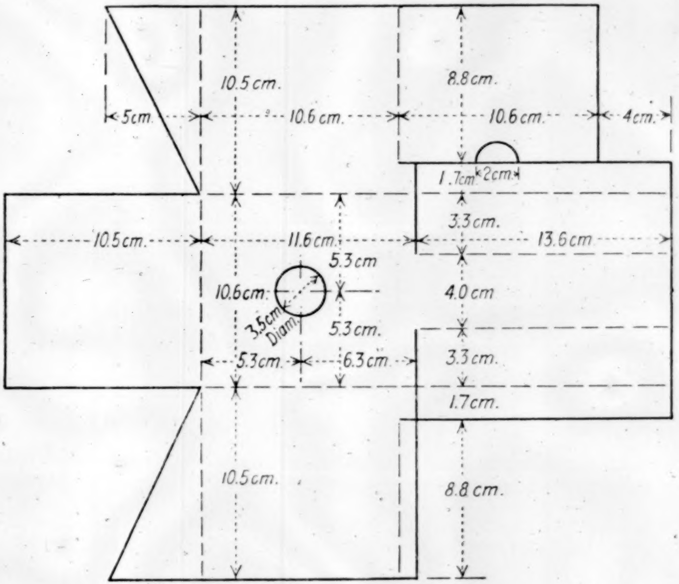

FIG. 2.—Asbestos Shield.

CASE: The thermometer shall be supplied in a suitable case on which shall appear the marking: "A.S.T.M. High Distillation, 0 to 400° C." or "A.S.T.M. High Distillation, 30 to 760° F." according to the type of thermometer.

NOTE.—For the purpose of interpreting these specifications the following definitions apply:

The total length is the over-all length of the finished instrument.

The diameter is that measured with a ring gage.

The length of the bulb is the distance from the bottom of the bulb to the beginning of the enamel backing.

The top of the thermometer is the top of the finished instrument.

II. PREPARATION OF SAMPLE

Sample.

7. The sample as received should be thoroughly stirred and agitated, warming if necessary to insure a complete mixture free from crystallized solids, before the portion for analysis is removed.

Dehydration. 8. If the presence of water is suspected or known, the oil shall be dehydrated before distillation in accordance with the method for dehydration as given in Sections 2 to 4 of the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials.[1]

III. PROCEDURE

Assembling Apparatus. 9. The flask shall be supported on a tripod or rings over two sheets of 20-mesh gauze, 150 mm. square, as shown in Fig. 3. It shall be connected to the condenser tube by a tight cork joint. The thermometer shall be inserted through a cork in the tubulature with the bottom of the bulb 12 to 13 mm. from the surface of the oil in the retort. The exact location of the thermometer bulb shall be determined by placing a vertical rule graduated in divisions not exceeding 1 mm. back of the retort, when the latter is in position for the test, and sighting the level of the liquid and the point for the bottom of the thermometer bulb.

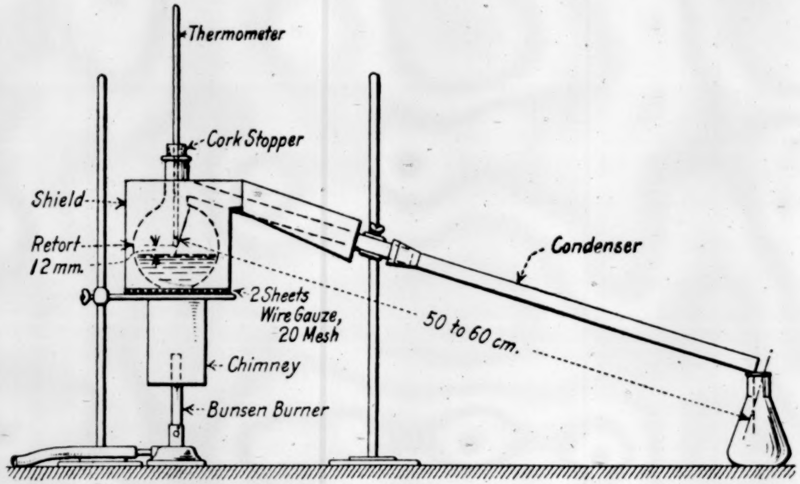

FIG. 3.—Distillation Apparatus Assembly.

The axis of the bulb through the tubulature shall be vertical.

The distance from the bulb of the thermometer to the outlet end of the condenser tube shall be not more than 600 nor less than 500 mm. The burner should be protected from draughts by a suitable shield or chimney, see Fig. 3.

Distillation Test. 10. (*a*) One hundred grams (100 g. ± 0.1 g.) of the sample shall be weighed into the flask, the apparatus assembled and heat applied so that the first drop comes over in from 5 to 15 minutes. The distillation shall be conducted at the rate of between 80 and 120 drops per minute and the distillate collected in weighed receivers. The condenser tube shall be warmed whenever necessary to prevent accumulation of solid distillates. Fractions shall be collected at the points designated by the specifications. The receivers shall be changed as the mercury passes the dividing temperature for each fraction. When the maximum specified temperature of the test is indicated by the thermometer, the flame shall be removed and any oil which has condensed in the condenser tube shall be drained into the last fraction.

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[1] 1924 Book of A.S.T.M. Standards.

(*b*) The residue shall remain in the flask with the cork and the thermometer in position until no vapors are visible; it shall then be weighed. The flask shall then be tipped around so that the residue will flow around the sides, thus collecting any condensed vapors that have collected on the sides of the flask, after which the residue shall be poured into the brass collar used in the float test or into a suitable receptacle and covered. If the residue becomes so cool that it cannot be poured readily from the flask, it shall be reheated to a temperature not exceeding 125° C. by holding the bulb of the flask in a suitable bath and not by the application of flame.

(*c*) For weighing the receivers and fractions, a balance accurate to at least 0.05 g. shall be used.

(*d*) During the progress of the distillation the thermometer shall remain in its original position. No correction shall be made for the emergent stem of the thermometer.

(*e*) The following fractions should be reported:[1]

0 - 210° C.
210 - 235° C.
235 - 270° C.
270 - 315° C.
315 - 355° C.
Residue.

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[1] The fraction 235-270° C. is not usually required in creosote specifications, but it is recommended that this cut be made, since it gives useful information and does not materially increase the operator's labor.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT ROLL-ROOFING SURFACED WITH POWDERED TALC[1]

Serial Designation: D 224 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope. 1. These specifications cover smooth-surfaced roll-roofing (medium and heavy weights), either 36 in. or 32 in. in width, composed of roofing felt saturated and coated on both sides with asphalt, and surfaced top and bottom with powdered talc or mica. The medium weight roofing is intended for use on semi-permanent structures and the heavy weight roofing for use on permanent structures.

I. MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on both sides with powdered talc or mica.

Character of Felt. 3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth, and upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

Character of Saturant and Coatings. 4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

Character of Felt after Saturation. 5. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Character of Mineral Surfacings. 6. The surfacing shall be non-combustible material such as powdered talc or mica.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

II. PHYSICAL PROPERTIES

7. The fabricated product shall conform to the following requirements:

(*a*) *Width of Roll.*—Either 36 or 32 in., as may be specified, ± ¼ in.

(*b*) *Area of Roll.*—The average area of the rolls examined shall contain as specified not less than either 108 sq. ft. or 216 sq. ft., which shall be sufficient to cover one or two "squares," respectively.

(*c*) *Weight of Wrapping, Packing, Nails and Cement per "Square,"* maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weight may be increased.

(*d*) *Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement.*—

Medium weight, average, not less than 42 lb., minimum, 40 lb.
Heavy weight, average, not less than 52 lb., minimum, 49 lb.

(*e*) *Pliability at 77° F. (25° C.).*—At least four strips out of five shall not crack on 10-mm. mandrel.

(*f*) *Behavior on Heating to 176° F. (80° C.) for 2 Hours.*—Volatile matter, maximum, 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings.

(*g*) *Saturant in Moisture-free Felt.*—Medium and heavy weights, minimum, 140 per cent by weight.

(*h*) *Weight of Moisture-free Desaturated Felt per 108 sq. ft.*—

Medium weight, minimum, 10.8 lb. ("Number" 48).
Heavy weight, minimum, 13.5 lb. ("Number" 60).

(*i*) *Ash in Moisture-free Desaturated Felt.*—Maximum, 10 per cent.

(*j*) *Weight of Mineral Surfacings and Mineral Matter in Coatings per 108 sq. ft.*—Medium and heavy weights, maximum, 2 lb.

NOTE.—Should the weight exceed 2 lb. the material shall nevertheless be acceptable, provided the finished weights per 108 sq. ft. are increased by a like amount over the figures specified in Paragraph (*d*).

III. WORKMANSHIP AND FINISH

Finished Appearance.

8. The surfaces shall be smooth or veined. Deeply ribbed surfaces shall not be acceptable.

Freedom from Defects.

9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Distribution of Coatings and Surfacing. 10. The coating and mineral surfacing shall be applied uniformly up to the edges of the sheet.

Adhesion of Surfacing. 11. The mineral surfacing shall uniformly cover both sides of the sheet.

Stickiness. 12. The coating and surfacing shall be of such a nature that the finished product will not crack, or be sticky enough to cause tearing or material damage, upon being unrolled at atmospheric temperatures above 50° F. (10° C.).

IV. PACKING

13. (*a*) The roofing shall be put up in rolls of 108 sq. ft. or 216 sq. ft. as specified in the order. No roll shall contain more than two pieces of roofing, nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the rolls shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll, or in bulk as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Each roll shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller and shall contain printed directions for laying. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller.

(*b*) *Nails.*—The gage of the wire shall not be greater than "A.S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. thick; the shank shall be between $\frac{3}{4}$ and 1 in. long, with its lower end pointed, and shall be either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" not less than an average of 252 nails for 36-in., and not less than an average of 275 nails for 32-in. roofing.

(*c*) *Lap-cement.*—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71° F. (21.5° C.) when tested by the Tagliabue Closed-cup Tester. There shall be furnished for each square of 36-in. roofing not less than $\frac{3}{4}$ pint and for 32-in.

roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased by $\frac{1}{4}$ pint per "square."

V. SAMPLING AND TESTING

14. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (Serial Designation: D 228 - 26 T) of the American Society for Testing Materials.[1]

VI. INSPECTION

15. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 992.

TENTATIVE SPECIFICATIONS
FOR
SLATE-SURFACED ASPHALT ROLL-ROOFING AND SLATE-SURFACED ASPHALT SHINGLES[1]

Serial Designation: D 225 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. **It is not a Standard of the Society and is subject to annual revision.**

ISSUED, 1925; REVISED, 1926.

Scope. 1. These specifications cover slate-surfaced roll roofing, either 36 or 32 in. in width, and slate-surfaced composition shingles, composed of roofing-felt saturated and coated on both sides with asphalt and surfaced on the weather side with granulated slate (green, red, black, or such color or combinations of color as may be agreed upon between the purchaser and seller), or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica to prevent the roofing or shingles adhering together in the package. Such roofing and shingles are intended for use on semi-permanent and permanent buildings.

I. MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on the weather side with granulated slate or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica.

Character of Felt. 3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing **Materials, 441** Lexington Ave., **New York City.**

Character of Saturant and Coatings.

4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

Character of Felt after Saturation.

5. The felt shall be thoroughly and uniformily saturated, and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Character of Mineral Surfacing.

6. The surfacing on the weather side shall be granular crushed slate or similar mineral material, as may be specified by the purchaser (in either green, red, blue-black or such other color or combinations of color as may be agreed upon between the purchaser and seller), shall be sufficiently free from fines or dust to permit the firm adhesion of the larger particles of the surfacing and provide a uniform distribution. The under side of the sheet shall be surfaced with a non-combustible material such as powered mica or talc.

II. PHYSICAL PROPERTIES

7. The fabricated product shall conform to the following requirements:

(*a*) *Width of Roll; Size and Form of Shingles:* Slate roll-roofing shall be either 36 or 32 in. in width, as may be specified, ±¼ in.

Shingles shall be of a size and form as may be agreed upon between the purchaser and seller.

(*b*) *Area per Package: Slate-Roll.*—The average area of the rolls examined shall contain not less than 108 sq. ft., which shall be sufficient to cover one "square".

Shingles.—Sufficient material shall be furnished per "square" as may be agreed upon between the purchaser and seller to adequately waterproof, when laid, the surface to which the shingles are applied.

(*c*) *Weight of Wrapping and Packing Material per "Square": Slate Roll* including nails and lap-cement, maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weights may be increased.

Shingles (packing only), maximum 12 lb.

(*d*) *Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement.*—*Slate Roll and Shingles.*—Average, not less than 82 lb., minimum, 80 lb.

(e) *Pliability at 77° F. (25° C.): Slate Roll.*—At least four strips out of five shall not crack on 25-mm. mandrel. *Shingles.*—No requirements.

(f) *Behavior on Heating to 176° F. (80° C.) for 2 hours.*—Volatile matter, maximum 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings. Granular surfacings shall not slide more than $\frac{1}{16}$ in. when suspended vertically.

(g) *Saturant in Moisture-Free Felt:*
Slate Roll, minimum, 140 per cent by weight.
Shingles, minimum, 150 per cent by weight.

(h) *Weight of Moisture-Free Desaturated Felt per 108 sq. ft.*—Slate roll and shingles, minimum 10.8 lb. ("Number" 48).

(i) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 10 per cent.

(j) *Weight of Mineral Surfacings and Mineral Matter in Coating per 108 sq. ft.*—Slate roll and shingles, maximum 35 lb.

III. WORKMANSHIP AND FINISH

Finished Appearance. 8. The weather surface shall be uniform in finish and texture.

Freedom from Defects. 9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Distribution of Coatings and Surfacings. 10. The coating and granules shall be applied in a uniformly smooth layer over the entire weather surface, except that slate-roll roofing may be provided with a bare lapping edge, 2 in. wide, along one edge of the sheet, where either the slate alone, or both the slate and coating may be omitted. The under surface of the sheet shall have the asphalt coating and mineral surfacing applied uniformily to the edges.

Adhesion of Surfacing. 11. The granular surfacing shall be embedded in the coating in such a manner that when rubbed vigorously with the hand, sufficient surfacing will remain embedded to completely cover the coating.

Stickiness. 12. For slate-roll-roofing, the coating and surfacings shall be of such a nature that the finished product will not crack or stick together so as to cause tearing or damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.). For shingles, the coating and surfacings shall be of such a nature that the finished products will not adhere together in the bundles so as to tear off or loosen the coating when unpacked.

IV. PACKING

13. (*a*) Slate roll-roofing shall be put up in rolls of 108 sq. ft. No rolls shall contain more than two pieces nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the roll shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll or in bulk, as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller.

Shingles shall be packed in bundles weighing not more than 135 lb. gross. The bundles shall either be packed in cardboard cartons or between wooden or cardboard ends and tied with rope, wire or steel bands so as to make a substantial package, as may be agreed upon by the purchaser and seller. Each roll or package shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller, and shall contain printed directions for laying.

(*b*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall be not less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. thick; the shank shall be between $\frac{3}{4}$ and 1 in. long for slate-roll roofing, and for shingles 1 in. long when laid on solid sheathing, or $1\frac{1}{2}$ to $1\frac{3}{4}$ in. when laid over old shingles. The lower end of the shank shall be pointed, and either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" of slate-roll roofing not less than an average of 252 nails for 36 in., and not less than an average of 275 nails for 32-in. roofing. For shingles, the nails shall be purchased separately, and the number required per "square" will depend upon the size and form of the shingles and shall be agreed upon by the purchaser and seller.

(*c*) *Lap-cement* (*for Slate Roll.*)—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of

71° F. (21.5° C.) when tested by the Tagliabue Closed-cup Tester. There shall be furnished for each square of 36-in. roofing not less $\frac{3}{4}$ pint and for 32-in. roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased $\frac{1}{4}$ pint per "square."

V. SAMPLING AND TESTING

14. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (Serial Designation: D 228 - 26 T) of the American Society for Testing Materials.[1]

VI. INSPECTION

15. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 992.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT ROLL-ROOFING SURFACED WITH GRANULAR TALC[1]

Serial Designation: D 248 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope.

1. These specifications cover roll-roofing (medium and heavy weights) either 36 or 32 in. in width, composed of roofing felt saturated and coated on both sides with asphalt, and surfaced on the face with granular talc, and on the back with powdered talc or mica. The medium weight is intended for use on semi-permanent structures, and the heavy weight on permanent structures.

I. MANUFACTURE

Manufacture.

2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on the weather side with granular talc, and on the reverse side with powdered talc or mica.

Character of Felt.

3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

Character of Saturant and Coatings.

4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

Character of Felt after Saturation.

5. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2-in. strips at

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

random across the entire sheet and splitting them open for their full length.

Character of Mineral Surfacing.

6. The surfacing on the weather side of the sheet shall be coarsely crushed talc and of a color as may be agreed upon between the purchaser and seller. It shall be of such a character as to permit the firm adhesion of the larger particles of surfacing and provide a uniform distribution. The under side of the sheet shall be surfaced with a non-combustible material such as powdered mica or talc.

II. PHYSICAL PROPERTIES

Physical Properties.

7. The fabricated product shall conform to the following requirements:

(*a*) *Width of Roll.*—Either 36 or 32 in., as may be specified, ± $\frac{1}{4}$ in.

(*b*) *Area of Roll.*—The average area of the rolls examined shall contain, as specified, not less than either 108 sq. ft. or 216 sq. ft., which shall be sufficient to cover one or two "squares" respectively.

(*c*) *Weight of Wrapping, Packing, Nails and Cement per "Square."*—Maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weight may be increased.

(*d*) *Weight of Material per 108 sq. ft. Exclusive of Wrapping Packing, Loose Mineral Surfacing, Nails and Cement:*

Medium Weight, average, 52 lb.; minimum, 50 lb.
Heavy Weight, average, 62 lb.; minimum, 59 lb.

(*e*) *Pliability at 77° F. (25° C.).*—At least 3 strips out of 5 shall not crack on 10-mm. mandrel.

(*f*) *Behavior on Heating to 176° F. (80° C.) for 2 hours.*—Volatile matter, maximum, 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings.

(*g*) *Saturant in Moisture-Free Felt:*

Medium and Heavy Weights, minimum, 140 per cent by weight.

(*h*) *Weight of Moisture-Free Desaturated Felt per 108 sq. ft.*—

Medium weight, minimum, 10.8 lb. ("Number" 48).
Heavy weight, minimum, 13.5 lb. ("Number" 60).

(*i*) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 10 per cent.

(*j*) *Weight of Mineral Surfacings and Mineral Matter in Coating per 108 sq. ft.*—

Medium and Heavy Weights, maximum, 11 lb.

Medium and Heavy Weights, passing a 65-mesh sieve, Maximum, 3 lb.

III. WORKMANSHIP AND FINISH

Finished Appearance. 8. The surfaces shall be smooth or veined. Deeply ribbed surfaces shall not be acceptable.

Freedom from Defects. 9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Distribution of Coatings and Surfacing. 10. The coating and mineral surfacing shall be applied uniformly up to the edges of the sheet.

Adhesion of Surfacing. 11. The mineral surfacing shall uniformly cover both sides of the sheet.

Stickiness. 12. The coating and surfacing shall be of such a nature that the finished product will not crack, or be sticky enough to cause tearing or material damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.).

IV. PACKING

Packing. 13. (*a*) The roofing shall be put up in rolls of 108 sq. ft. or 216 sq. ft., as specified in the order. No roll shall contain more than two pieces of roofing, nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the rolls shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll or in bulk, as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Each roll shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller and shall contain printed directions for laying. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller.

(*b*) *Nails.*—The gage of the wire shall not be greater than "A.S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall not be less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness. The shank shall be between $\frac{3}{4}$ and 1 in. long, with its lower end pointed, and shall be either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electro-galvanized or sherardized coatings will be accepted. There shall be furnished per "square" not less than an average of 252 nails for 36-in., and not less than an average of 275 nails for 32-in. roofing.

(*c*) *Lap-cement.*—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71° F. (21.5° C.) when tested by the Tagliabue Closed-Cup Tester. There shall be furnished for each square of 36-in. roofing not less than $\frac{3}{4}$ pint and for 32-in. roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased by $\frac{1}{4}$ pint per "square."

V. SAMPLING AND TESTING

Sampling and Testing.

14. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (Serial Designation: D 228 - 26 T) of the American Society for Testing Materials.[1]

VI. INSPECTION

Inspection.

15. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 992.

TENTATIVE SPECIFICATIONS
FOR
HEAVY WEIGHT SLATE-SURFACED ASPHALT ROLL-ROOFING AND HEAVY WEIGHT SLATE-SURFACED ASPHALT SHINGLES[1]

Serial Designation: D 249 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. These specifications cover slate-surfaced roll roofing, either 36 or 32 in. in width, and slate-surfaced composition shingles, composed of roofing-felt saturated and coated on both sides with asphalt and surfaced on the weather side with granulated slate (green, red, black, or such color or combinations of color as may be agreed upon between the purchaser and seller), or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica to prevent the roofing or shingles adhering together in the package. Such roofing and shingles are intended for use on semi-permanent and permanent buildings.

I. MANUFACTURE

Manufacture 2. In the process of manufacture, a single thickness of dry roofing felt shall be impregnated with an asphaltic saturant, then coated on both sides with an asphaltic coating, and finally surfaced on the weather side with granulated slate or similar mineral material to be specified by the purchaser, and on the reverse side with powdered talc or mica.

Character of Felt. 3. The felt shall be a roofing felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

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[1] Criticisms of these Tentative Specifications are solicited, and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

Character of Saturant and Coatings.

4. The saturant and coatings shall be composed principally of asphaltic materials, and the presence of saponifiable constituents shall be permitted.

Character of Felt after Saturation.

5. The felt shall be thoroughly and uniformly saturated, and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Character of Mineral Surfacing.

6. The surfacing on the weather side shall be granular crushed slate or similar mineral material, as may be specified by the purchaser (in either green, red, blue-black or such other color or combinations of color as may be agreed upon between the purchaser and seller), shall be sufficiently free from fines or dust to permit the firm adhesion of the larger particles of the surfacing and provide a uniform distribution. The under side of the sheet shall be surfaced with a non-combustible material such as powdered mica or talc.

II. PHYSICAL PROPERTIES

Physical Properties.

7. The fabricated product shall conform to the following requirements:

(*a*) *Width of Roll: Size and Form of Shingles.*—Slate roll-roofing shall be either 36 or 32 in. in width, as may be specified, ± ¼ in.

Shingles shall be of a size and form as may be agreed upon between the purchaser and seller.

(*b*) *Area per Package: Slate-Roll.*—The average area of the rolls examined shall contain not less than 108 sq. ft., which shall be sufficient to cover one "square."

Shingles.—Sufficient material shall be furnished per "square" as may be agreed upon between the purchaser and seller to adequately waterproof, when laid, the surface to which the shingles are applied.

(*c*) *Weight of Wrapping and Packing Material per "Square": Slate Roll* including nails and lap-cement, maximum, 4 lb.

NOTE.—Special fixtures may be furnished in lieu of nails and cement, if agreed upon by the purchaser and seller, in which event the above weight may be increased.

Shingles (packing only), maximum 12 lb.

(*d*) *Weight of Material per 108 sq. ft. Exclusive of Wrapping, Packing, Loose Mineral Surfacing, Nails and Cement:*

Slate Roll and *Shingles.*—Average, 105 lb., minimum, 100 lb.

(*e*) *Pliability at 77° F. (25° C.):*
Slate Roll and *Shingles.*—No requirements.

(*f*) *Behavior on Heating to 176° F. (80° C.) for 2 hours.*—Volatile matter, maximum 1.5 per cent. There shall be no flowing, sagging, blistering or absorption of the surface coatings. Granular surfacings shall not slide more than $\frac{1}{16}$ in. when suspended vertically.

(*g*) *Saturant in Moisture-Free Felt:*
Slate Roll and *Shingles.*—Minimum 170 per cent by weight.

(*h*) *Weight of Moisture-Free Desaturated Felt per 108 sq. ft.:*
Slate Roll and *Shingles.*—Minimum 15.75 lb. ("Number" 70).

(*i*) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 10 per cent.

(*j*) *Weight of Mineral Surfacings and Mineral Matter in Coating per 108 sq. ft.: Slate Roll* and *Shingles.*—Maximum 40 lb.

III. WORKMANSHIP AND FINISH

Finished Appearance. 8. The weather surface shall be uniform in finish and texture.

Freedom from Defects. 9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Distribution of Coatings and Surfacing. 10. The coating and granules shall be applied in a uniformly smooth layer over the entire weather surface, except that slate-roll roofing may be provided with a bare lapping edge, 2 in. wide, along one edge of the sheet, where either the slate alone, or both the slate and coating may be omitted. The under surface of the sheet shall have the asphalt coating and mineral surfacing applied uniformly to the edges.

Adhesion of Surfacing. 11. The granular surfacing shall be embedded in the coating in such a manner that when rubbed vigorously with the hand, sufficient surfacing will remain embedded to completely cover the coating.

Stickiness. 12. For slate-roll-roofing, the coating and surfacings shall be of such a nature that the finished product will not crack or stick together so as to cause tearing or damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.). For shingles, the coating and surfacings shall be of such a nature that the finished products will not adhere together in the bundles so as to tear off or loosen the coating when unpacked.

IV. PACKING

Packing.

13. (*a*) Slate-roll-roofing shall be put up in rolls of 108 sq. ft. No rolls shall contain more than two pieces nor shall there be more than 3 per cent of rolls containing two pieces in any shipment. The rolls shall be tightly wound and securely wrapped in a substantial grade of paper. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the roll shall be protected with metal caps, cloth or other suitable means. The nails and lap-cement shall be furnished either in each roll or in bulk, as specified in the order. When furnished in bulk, the cloth or metal ends may be omitted. Rolls for export shipment shall be packed as agreed upon by the purchaser and seller.

Shingles shall be packed in bundles weighing not more than 135 lb. gross. The bundles shall either be packed in cardboard cartons or between wooden or cardboard ends and tied with rope, wire or steel bands so as to make a substantial package, as may be agreed upon by the purchaser and seller. Each roll or package shall be plainly marked with the manufacturer's name and brand or as agreed upon by the purchaser and seller, and shall contain printed directions for laying.

(*b*) *Nails.*—The gage of the wire shall not be greater than "A. S. & W." No. 10 (0.135 in.) nor thinner than No. 12 (0.105 in.); the head shall be not less than $\frac{3}{8}$ in. in diameter, and not less than 0.025 in. in thickness; the shank shall be between $\frac{3}{4}$ and 1 in. long for slate-roll-roofing, and for shingles 1 in. long when laid on solid sheathing, or $1\frac{1}{2}$ to $1\frac{3}{4}$ in. when laid over old shingles. The lower end of the shank shall be pointed, and either smooth or barbed, and if the latter, then the barbings shall not increase the diameter of the lower two-thirds more than 0.01 in. The nails shall be zinc coated with not less than $\frac{1}{2}$ oz. nor more than $1\frac{1}{4}$ oz. per sq. ft. of nail surface. Hot-galvanized, electrogalvanized, or sherardized coatings will be accepted. There shall be furnished per "square" of slate-roll-roofing not less than an average of 252 nails for 36-in., and not less than an average of 275 nails for 32-in. roofing. For shingles, the nails shall be purchased separately, and the number required per "square" will depend upon the size and form of the shingles and shall be agreed upon by the purchaser and seller.

(*c*) *Lap-Cement* (*for Slate Roll*).—The cement shall be composed of bituminous materials dissolved in a volatile solvent, and shall be of such a nature as to firmly bind the laps without injurious effect upon the roofing. The cement shall have a minimum flash point of 71° F. (21.5° C.) when tested by the Tagliabue Closed-Cup Tester. There shall be furnished for each square of 36-in. roofing not less than $\frac{3}{4}$ pint and for 32-in. roofing not less than 1 pint. The addition of 5 to 20 per cent by weight of short-fibered asbestos shall be permitted, in which case the quantity of cement shall be increased $\frac{1}{4}$ pint per "square."

V. SAMPLING AND TESTING

Sampling and Testing.

14. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles (Serial Designation: D 228 – 26 T) of the American Society for Testing Materials.[1]

VI. INSPECTION

Inspection.

15. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 992.

TENTATIVE SPECIFICATIONS

FOR

ASPHALT-SATURATED ROOFING FELT FOR USE IN WATERPROOFING AND IN CONSTRUCTING BUILT-UP ROOFS[1]

Serial Designation: D 226 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope.

1. These specifications cover asphalt-saturated felt, either 36 or 32 in. in width, composed of roofing felt saturated, but not coated, with asphalt for use in the membrane system of waterproofing and in the construction of built-up roofs.

I. MANUFACTURE

Manufacture.

2. In the process of manufacture, a single thickness of dry roofing felt shall be saturated with an asphaltic saturant.

Character of Felt.

3. The felt shall be a roofing-felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

Character of Saturant.

4. The saturant shall be composed of asphaltic materials.

Character of Felt after Saturation.

5. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Surfacing.

6. The surface of the felt shall not be coated or covered with talc or other substance which would tend to interfere with the adhesion between the felt and the plying cement.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

II. PHYSICAL PROPERTIES

Fabricated Bituminized Felt.

7. The fabricated bituminized felt shall conform to the following requirements:

(*a*) *Width of Roll.*—Either 36 or 32 in., as may be specified, ± $\frac{1}{4}$ in.

(*b*) *Gross Weight per Roll.*—40 to 80 lb.

(*c*) *Weight of Wrapping and Packing Material per Roll.*—Maximum $\frac{1}{2}$ lb.

(*d*) *Weight of Material per 100 sq. ft. Exclusive of Packing and Wrapping.*—14 lb. ± 1 lb.

(*e*) *Loss on Heating at 105° C. (221° F.) for 5 hours.*—Maximum, 4 per cent.

(*f*) *Pliability at 77° F. (25° C.).*—At least four strips out of five shall not crack when bent through 180 deg. over a $\frac{1}{16}$-in. mandrel.

(*g*) *Saturant in Moisture-Free Felt.*—Minimum 140 per cent by weight.

Desaturated Felt.

8. The desaturated felt shall conform to the following requirements:

(*a*) *Weight of Moisture-Free Desaturated Felt.*—Minimum, 5.2 lb. per 100 sq. ft. ("Number" 25).

(*b*) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 10 per cent.

III. WORKMANSHIP AND FINISH

Freedom from Defects.

9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Stickiness.

10. The rolls shall not crack, or be sticky enough to cause tearing or material damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.)

IV. PACKING

11. The rolls of saturated felt need not be wound on cores, but they shall be securely wrapped in a substantial grade of paper of the same width as the fabric. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the roll need not be covered. As an alternative, the rolls of saturated felt may either be tied with strings or simply pasted at the ends, as may be agreed upon by the purchaser and seller. No roll shall contain more than two pieces,

and there shall not be more than 3 per cent of rolls containing two pieces in any shipment. Each roll shall be plainly marked with the manufacturer's name and brand or as agreed by the purchaser and seller, and shall bear a notation showing the type of saturant.

V. SAMPLING AND TESTING

12. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (Serial Designation: D 146 – 26 T) of the American Society for Testing Materials.[1]

VI. INSPECTION

13. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 983.

TENTATIVE SPECIFICATIONS
FOR
COAL-TAR SATURATED ROOFING FELT FOR USE IN WATERPROOFING AND IN CONSTRUCTING BUILT-UP ROOFS[1]

Serial Designation: D 227 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope. 1. These specifications cover coal-tar saturated felt, either 36 or 32 in. in width, composed of roofing felt saturated, but not coated, with refined coal tar, for use in the membrane system of waterproofing and in the construction of built-up roofs.

I. MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of dry roofing felt shall be saturated with a coal-tar saturant.

Character of Felt. 3. The felt shall be a roofing-felt produced by "felting" vegetable and animal fibers. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps of underbeaten stock (*i.e.*, stock which has not been beaten or shredded into fiber in the process of manufacture) and particles of foreign substances (*i.e.*, fragments of stone, metal, leather, rubber, straw, wood, etc.).

Character of Saturant. 4. The saturant shall be composed of coal tar from which the highly volatile constituents have been removed.

Character of Felt after Saturation. 5. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Surfacing. 6. The surface of the felt shall not be coated or covered with talc or other substance which would tend to interfere with the adhesion between the felt and the plying cement.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

II. PHYSICAL PROPERTIES

Fabricated Bituminized Felt.

7. The fabricated bituminized felt shall conform to the following requirements:

(*a*) *Width of Roll.*—Either 36 or 32-in., as may be specified, $\pm \frac{1}{4}$ in.

(*b*) *Gross Weight per Roll.*—40 to 80 lb.

(*c*) *Weight of Wrapping and Packing Material per Roll.*—Maximum, $\frac{1}{2}$ lb.

(*d*) *Weight of Material per 100 sq. ft. Exclusive of Packing and Wrapping.*—14 lb. ± 1 lb.

(*e*) *Moisture.*—Maximum, 2.5 per cent of the net weight.

(*f*) *Distillate,* per cent by weight to 210° C., calculated on extracted saturant, not more than 2.

Distillate, per cent by weight to 235° C., calculated on extracted saturant, not more than 5.

(*g*) *Pliability at 77° F. (25° C.).*—At least four strips out of five shall not crack when bent through 180 deg. over a $\frac{1}{16}$-in. mandrel.

(*h*) *Saturant in Moisture-Free Felt.*—Minimum, 140 per cent by weight.

Desaturated Felt.

8. The desaturated felt shall conform to the following requirements:

(*a*) *Weight of Moisture-Free Desaturated Felt.*—Minimum, 5.2 lb. per 100 sq. ft. ("Number" 25).

(*b*) *Ash in Moisture-Free Desaturated Felt.*—Maximum, 10 per cent.

III. WORKMANSHIP AND FINISH

Freedom from Defects.

9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Stickiness.

10. The rolls shall not crack, or be sticky enough to cause tearing or material damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.).

IV. PACKING

Packing.

11. The rolls of saturated felt need not be wound on cores, but they shall be securely wrapped in a substantial grade of paper of the same width as the fabric. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the roll need not be covered. As an alternative, the rolls of saturated felt may either be tied with strings or simply pasted at the ends, as may be agreed upon by the

purchaser and seller. No roll shall contain more than two pieces, and there shall not be more than 3 per cent of rolls containing two pieces in any shipment. Each roll shall be plainly marked with the manufacturer's name and brand or as agreed by the purchaser and seller, and shall bear a notation showing the type of saturant.

V. SAMPLING AND TESTING

12. The material shall be sampled and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (Serial Designation: D 146 - 26 T) of the American Society for Testing Materials.[1]

VI. INSPECTION

13. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 983.

TENTATIVE SPECIFICATIONS
FOR
ASPHALT-SATURATED ASBESTOS FELT FOR USE IN CONSTRUCTING BUILT-UP ROOFS[1]

Serial Designation: D 250 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. These specifications cover asphalt-saturated asbestos felt, either 32 or 36 in. in width, composed of asbestos felt saturated, but not coated, with asphalt, for use in the construction of built-up roofs.

I. MANUFACTURE

Manufacture. 2. In the process of manufacture, a single thickness of asbestos felt shall be saturated with an asphaltic saturant.

Character of Felt. 3. The felt shall be an asbestos felt produced by "felting" at least 85 per cent by weight of asbestos fiber. The surface of the felt shall be uniformly smooth and, upon splitting or tearing on the bias, shall appear reasonably free from lumps or particles of foreign substances.

Character of Saturant. 4. The saturant shall be composed of asphaltic materials.

Character of Felt after Saturation. 5. The felt shall be thoroughly and uniformly saturated and shall show no unsaturated spots at any point upon cutting 2-in. strips at random across the entire sheet and splitting them open for their full length.

Surfacing. 6. The surface of the felt shall not be coated or covered with talc or other substance which would tend to interfere with the adhesion between the felt and the plying cement.

II. PHYSICAL PROPERTIES

Fabricated Asphalt-Saturated Felt. 7. The fabricated asphalt-saturated felt shall conform to the following requirements:

(*a*) *Width of Roll.*—Either 36 or 32 in., as may be specified, $\pm \frac{1}{4}$ in.

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[1] Criticisms of these Tentative Specifications are solicited, and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

(*b*) *Gross Weight per Roll.*—40 to 80 lb.

(*c*) *Weight of Wrapping and Packing Material per Roll.*—Maximum ½ lb.

(*d*) *Weight of Material per 100 sq. ft. Exclusive of Packing and Wrapping.*—14 lb. ± 1 lb.

(*e*) *Loss on Heating at 105° C. (221° F.) for 5 hours.*—Maximum, 2 per cent.

(*f*) *Pliability at 77° F. (25° C.).*—Shall not crack when bent through 180 deg. over a $\frac{1}{16}$-in. mandrel.

(*g*) *Average Breaking Strength.*—With the fiber grain 25 lb., across the fiber grain 13 lb.

(*h*) *Saturant in Moisture-Free Felt.*—Minimum 50 per cent by weight.

Desaturated Felt.

8. The desaturated felt shall conform to the following requirements:

(*a*) *Weight of Moisture-Free Desaturated Felt.*—The minimum weight per 100 sq. ft. shall be 9 lb.

(*b*) *The Thickness of Desaturated Felt.*—Minimum, 0.020 in.

(*c*) *The Ash in Moisture-Free Desaturated Felt.*—Minimum, 73 per cent.

NOTE.—This presupposes the presence of at least 85 per cent of asbestos fiber carrying 14 per cent water of hydration.

III. WORKMANSHIP AND FINISH

Freedom from Defects.

9. The finished product shall be free from visible external defects, such as holes, ragged or untrue edges, breaks, cracks, tears, protuberances and indentations.

Stickiness.

10. The rolls shall not crack, or be sticky enough to cause tearing or material damage upon being unrolled at atmospheric temperatures above 50° F. (10° C.).

IV. PACKING

Packing.

11. The rolls of saturated felt need not be wound on cores, but they shall be securely wrapped in a substantial grade of paper of the same width as the fabric. The wrapper shall completely encircle the roll and shall be pasted at the overlap in a manner which will prevent it shifting from position. The ends of the rolls need not be covered. As an alternative, the rolls of saturated felt may either be tied with strings or simply pasted at the ends, as may be agreed upon by the purchaser and seller. No roll shall contain more than two pieces and there shall not be more than 3 per cent of rolls containing two pieces in any shipment. Each roll shall be plainly marked with the

manufacturer's name and brand or as agreed by the purchaser and seller and shall bear a notation showing the type of saturant.

V. SAMPLING AND TESTING

Sampling and Testing.

12. The material shall be sampled, and the properties enumerated in these specifications shall be determined in accordance with the Tentative Methods of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing (Serial Designation: D 146 - 26 T) of the American Society for Testing Materials.[1]

VI. INSPECTION

Inspection.

13. Inspection of material shall be made as agreed upon by the purchaser and seller as part of the purchase contract.

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[1] See p. 983.

TENTATIVE SPECIFICATIONS

FOR

HIGH-CARBON COAL-TAR PITCH FOR USE IN CONSTRUCTING BUILT-UP ROOFS SURFACED WITH SLAG OR GRAVEL[1]

Serial Designation: D 251 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope.

1. These specifications cover high-carbon coal-tar pitch intended for use as a mopping coat in the construction of built-up roofs surfaced with slag or gravel on inclines not exceeding 3 in. to the foot over boards and 1 in. to the foot over concrete, in connection with the Tentative Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (Serial Designation: D 227 - 26 T) of the American Society for Testing Materials.[2]

I. SAMPLING

Sampling.

2. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140) of the American Society for Testing Materials.[3]

II. PROPERTIES

Properties.

3. The coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water.....................................0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.)..........1.25 to 1.34
(*c*) Softening Point (Cube-in-Water Method)..140 to 150° F. (60.0 to 65.5° C.)
(*d*) Distillation Test:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

[2] See p. 969.

[3] A.S.T.M. Standards Adopted in 1925.

Total distillate, by weight, 0.0 to 300° C. (32 to 572° F.)..........not more than 12 per cent
Residue, by weight..................not less than 88 per cent

(*e*) Specific gravity at 38°/25° C. (100°/77° F.) of total distillate to 300° C. (572° F.)......................not less than 1.03
(*f*) Ductility at 25° C. (77° F.)........not less than 50 cm.
(*g*) Insoluble in carbon disulfide..........22 to 35 per cent
(*h*) Ash on incineration.........not more than 0.5 per cent

III. METHODS OF TESTING

Methods of Testing.

4. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95).[1]

(*b*) *Specific Gravity:* Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (Serial Designation: D 70 – 26 T).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[1]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20).[1]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 26 T).[3]

(*f*) *Insoluble in Carbon Disulfide:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 26 T).[4]

(*g*) *Ash:* Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22).[1]

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[1] 1924 Book of A.S.T.M. Standards.

[2] See p. 869.

[3] See p. 886.

[4] See p. 876.

TENTATIVE SPECIFICATIONS
FOR
HIGH-BITUMEN COAL-TAR PITCH FOR USE IN CONSTRUCTING BUILT-UP ROOFS SURFACED WITH SLAG OR GRAVEL[1]

Serial Designation: D 252 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision

ISSUED, 1926.

Scope. 1. These specifications cover high-bitumen coal-tar pitch intended for use as a mopping-coat in the construction of built-up roofs surfaced with slag or gravel on inclines not exceeding 3 in. to the foot over boards and 1 in. to the foot over concrete, in connection with the Tentative Specifications for Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs (Serial Designation: D 227 – 26 T) of the American Society for Testing Materials.[2]

I. SAMPLING

Sampling. 2. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140) of the American Society for Testing Materials.[3]

II. PROPERTIES

Properties. 3. The high-bitumen coal-tar pitch shall be homogeneous and shall conform to the following requirements:

(*a*) Water.....................................0.0 per cent
(*b*) Specific gravity at 25° C. (77° F.)..........1.22 to 1.32
(*c*) Softening Point (Cube-in-Water Method)...140 to 150° F. (60.0 to 65.5° C.)

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

[2] See p. 969.

[3] A.S.T.M. Standards Adopted in 1925.

(*d*) Distillation Test:

Total distillate, by weight, 0.0 to 300° C. (32 to 572° F.)............not more than 12 per cent
Residue, by weight...................not less than 88 per cent

(*e*) Specific gravity at 38°/25° C. (100°/77° F.) of total distillate to 300° C. (572° F.)........................not less than 1.03
(*f*) Ductility at 25° C. (77° F.)........not less than 50 cm.
(*g*) Total bitumen (Soluble in Carbon Disulfide)........................78 to 85 per cent
(*h*) Ash on incineration.........not more than 0.5 per cent

III. METHODS OF TESTING

Methods of Testing.

4. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Percentage of Water:* Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95).[1]

(*b*) *Specific Gravity:* Tentative Method of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches (Serial Designation: D 70 – 26 T).[2]

(*c*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[1]

(*d*) *Distillation:* Standard Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (Serial Designation: D 20).[1]

(*e*) *Ductility:* Tentative Method of Test for Ductility of Bituminous Materials (Serial Designation: D 113 – 26 T).[3]

(*f*) *Insoluble in Carbon Disulfide:* Tentative Method of Test for the Determination of Bitumen (Serial Designation: D 4 – 26 T).[4]

(*g*) *Ash:* Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22).[1]

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[1] 1924 Book of A.S.T.M. Standards.

[2] See p. 869.

[3] See p. 886.

[4] See p. 876.

TENTATIVE SPECIFICATIONS
FOR
LIGHT BODY COAL-TAR OR WATER-GAS-TAR PROTECTIVE COATING WITH SOLVENT VEHICLE, FOR COLD APPLICATION, FOR DAMP-PROOFING MASONRY STRUCTURES[1]

Serial Designation: D 253 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. These specifications cover a light body coal-tar or water-gas-tar protective coating of suitable consistency for application with a brush or spray.

2. This material is suitable for coating all sides except the face of cut stones, concrete blocks, etc., to prevent efflorescence, staining or other discoloration of the exposed face, when used in building.

I. SAMPLING

Sampling. 3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140) of the American Society for Testing Materials.[2]

II. PROPERTIES

Properties. 4. The coating material shall consist of a homogeneous mixture of a coal-tar or water-gas-tar pitch and a volatile solvent.

The original material shall have a viscosity at 25° C. (77° F.) by Saybolt-Furol of not less than 40 and not more than 60 seconds.

Steam Distillation. 5. (*a*) The volatile solvent, recovered by steam distillation, shall have the following characteristics:

Distillate to 120° C. (248° F.)	not over 5 per cent
Distillate to 170° C. (338° F.)	not less than 10 per cent
Distillate to 230° C. (446° F.)	not less than 90 per cent

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

[2] A.S.T.M. Standards Adopted in 1925.

(*b*) The base recovered by steam distillation shall have the following characteristics:

Softening point	60 to 75° C. (140 to 167° F.)
Ash on ignition	not more than 0.5 per cent

(*c*) The distillate obtained when the base is distilled to coke shall show not less than 90 per cent of polymerizable oil.

III. METHODS OF TESTING

Methods of Testing.

6. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Separation of Volatile Solvent and Base:* Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings (Serial Designation: D 255 – 26 T).[1]

(*b*) *Viscosity:* Saybolt-Furol, Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88).[2]

(*c*) *Distillation Test:* Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (Serial Designation: D 86 – 26 T).[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[4]

(*e*) *Ash:* Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22).[4]

(*f*) *Distillation to Coke:* 25 cc. of the material shall be placed in a 50-cc. distillation flask, and distilled to coke. The oil obtained shall be tested in accordance with the Standard Methods of Sampling and Testing Turpentine (Serial Designation: D 233)[2] for percentage of polymerizable oils.

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[1] See p. 998.

[2] A.S.T.M. Standards Adopted in 1926.

[3] See p. 816.

[4] 1924 Book of A.S.T.M. Standards.

TENTATIVE SPECIFICATIONS
FOR
HEAVY BODY COAL-TAR OR WATER-GAS-TAR PROTECTIVE COATING WITH SOLVENT VEHICLE, FOR COLD APPLICATION, FOR DAMP-PROOFING MASONRY STRUCTURES[1]

Serial Designation: D 254 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope.

1. These specifications cover a heavy body coal-tar or water-gas-tar protective coating of suitable consistency for application with a brush.

2. This material is suitable for coating the inside of exterior walls of concrete and masonry before plastering, to prevent staining of the plastering due to the penetration of water from outside, or the exterior surfaces of exposed walls and concrete masonry below ground level to prevent penetration of moisture.

I. SAMPLING

Sampling.

3. The sampling shall be performed in accordance with the Standard Methods of Sampling Bituminous Materials (Serial Designation: D 140) of the American Society for Testing Materials.[2]

II. PROPERTIES

Properties.

4. The coating shall consist of a homogeneous mixture of a coal-tar or water-gas-tar pitch and a volatile solvent.

The original materials shall have a viscosity at 25° C. (77° F.) by Saybolt-Furol of not less than 200 and not more than 250 seconds.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

[2] A.S.T.M. Standards Adopted in 1925.

Steam Distillation.

5. (*a*) The volatile solvent, recovered by steam distillation, shall have the following characteristics:

Distillate to 120° C. (248° F.)	not over 5 per cent
Distillate to 170° C. (338° F.)	not less than 10 per cent
Distillate to 230° C. (446° F.)	not less than 90 per cent

(*b*) The base recovered by steam distillation shall have the following characteristics:

Softening point	60 to 75° C. (140 to 167° F.)
Ash on ignition	not more than 0.5 per cent

(*c*) The distillate obtained when the base is distilled to coke shall show not less than 90 per cent of polymerizable oil.

III. METHODS OF TESTING

Methods of Testing.

6. The properties enumerated in these specifications shall be determined in accordance with the following methods of test of the American Society for Testing Materials:

(*a*) *Separation of Volatile Solvent and Base:* Tentative Method of Test for Steam Distillation of Bituminous Protective Coatings (Serial Designation: D 255 – 26 T).[1]

(*b*) *Viscosity:* Saybolt-Furol, Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88).[2]

(*c*) *Distillation Test:* Tentative Method of Test for Distillation of Gasoline, Naptha, Kerosine and Similar Petroleum Products (Serial Designation: D 86 – 26 T).[3]

(*d*) *Softening Point:* Standard Method of Test for Softening Point of Tar Products (Cube-in-Water Method) (Serial Designation: D 61).[4]

(*e*) *Ash:* Standard Methods of Laboratory Sampling and Analysis of Coal (Serial Designation: D 22).[4]

(*f*) *Distillation to Coke:* 25 cc. of the material shall be placed in a 50-cc. distillation flask, and distilled to coke. The oil obtained shall be tested in accordance with the Standard Methods of Sampling and Testing Turpentine (Serial Designation: D 233)[2] for percentage of polymerizable oils.

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[1] See p. 998.

[2] A.S.T.M. Standards Adopted in 1926.

[3] See p. 816.

[4] 1924 Book of A.S.T.M. Standards.

TENTATIVE METHODS OF TESTING FELTED AND WOVEN FABRICS SATURATED WITH BITUMINOUS SUBSTANCES FOR USE IN WATERPROOFING AND ROOFING[1]

Serial Designation: D 146 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1922; REVISED, 1923, 1925, 1926.

Scope. 1. These methods cover the examination of felted or woven fabrics saturated (but not coated) with asphalt or coal-tar products, for use in the "membrane" system of waterproofing.

I. SAMPLING.

Sampling 2. From each shipment or portion thereof representing a product of the same kind, class and weight, a number of rolls shall be selected at random, equivalent to one-half the cube root of the total number of rolls in the lot, except that in lots of 1000 or less, 5 rolls shall be taken. If the cube root, as calculated, proves to be a fractional number, it shall be expressed as the next higher whole number. For convenience, the following table is given, showing the number of samples to be selected for shipments of various sizes:

Packages in Shipment	Number of Packages Selected	Packages in Shipment	Number of Packages Selected
Up to 1000	5	5 833 to 8 000	10
1001 to 1728	6	8 001 to 10 648	11
1729 to 2744	7	10 649 to 13 842	12
2745 to 4096	8	13 843 to 17 576	13
4097 to 5832	9	17 577 to 21 952	14

II. EXAMINATION OF FINISHED FABRIC.

Width. 3. The width of each roll taken shall be measured to the nearest $\frac{1}{32}$ in. The minimum and maximum width so obtained shall be reported.

Gross Weight per Roll. 4. Each roll taken shall be weighed intact to the nearest $\frac{1}{4}$ lb. and the minimum and maximum gross weight shall be reported.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

Wrapping and Packing Materials. 5. Each roll sampled shall be stripped. All the wrappers and packing material shall be weighed together to the nearest $\frac{1}{4}$ lb. and the average maximum weight thereof per roll shall be reported.

Area per Roll. 6. Each roll shall be unwound, observing the workmanship and finish while so doing. The length and width of each roll shall thereupon be measured to the nearest $\frac{1}{4}$ in. and the square feet of material contained in each roll calculated.

Net Weight per Roll. 7. The rolls shall be rewound, fastened with pieces of light string and then each roll shall be weighed to the nearest $\frac{1}{4}$ lb. In the case of felted fabrics, calculate the weight of each roll in pounds per 100 sq. ft. and report the maximum and minimum, likewise recording the average for the rolls sampled, which shall be regarded as the corresponding weights of the entire shipment. In the case of woven fabrics, calculate the weight of each roll in ounces per square yard, and report the minimum, likewise recording the average for the rolls sampled, which shall be regarded as the corresponding weights of the entire shipment.

Weight per Unit Area. 8. From the rolls examined, select the one whose weight per unit area is nearest the average weight per unit area of the lot. The roll so selected shall be laid flat, the first convolution or two carefully unwound, and with a knife and straight edge the sheet shall be cleanly cut across at right angles to the edges. A section measuring 30 in. in the direction of the roll's length shall be removed. If the material is surfaced with sand or other fine material any detached particles belonging to each 30-in. section shall be retained. The width of each section shall be measured to the nearest $\frac{1}{32}$ in. Each section, together with any detached surfacing, shall be weighed to the nearest gram. The weight in pounds per 100 sq. ft. or the weight in ounces per sq. yd. shall be calculated from the formulas:

$$\text{Pounds per 100 sq. ft.} = 1.0582 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

$$\text{Ounces per sq. yd.} = 1.5238 \times \frac{\text{Weight of 30-in. section in grams}}{\text{Width of 30-in. section in inches}}$$

This must check within 1 per cent of the average weight per unit area of shipment (Section 7). If the sample fails to do this, then additional samples shall be cut from the same roll, until one is obtained which does, which sample shall be kept for further examination.

NOTE.—As a referee method or in case any dispute arises regarding the properties as may be ascertained from the particular sample selected, a 30-in. sample shall be taken and examined separately from each roll sampled in Section 2.

Detached Comminuted Surfacing. 9. If the material is surfaced with sand or other finely comminuted material, the surfacing shall be swept with a moderately stiff brush from all the 30-in. sections taken. All the material thus removed shall be caught and weighed to the nearest ounce. From the aggregate areas of all the sections taken, the average weight of detached comminuted surfacing shall be calculated in pounds per 100 sq. ft.

Thickness.

10. The thickness of each specimen shall be measured at 10 equally spaced points, 1 in. from a cut edge, with a micrometer gage having flat bearing surfaces at both contact points of not less than ½ in. in diameter and preferably of the spring-and-dial type. The readings for each roll sampled shall be averaged and the minimum, maximum and average thickness calculated to the nearest 0.001 in.

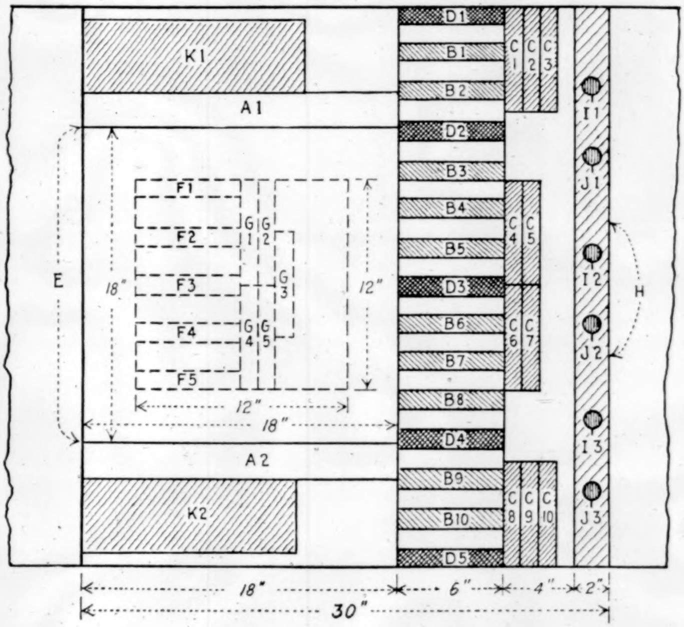

FIG. 1

Moisture.

11. From each specimen, 2-in. strips shall be cut as shown at *A-1* and *A-2* in Fig. 1. The 2-in. strips shall be cut into 1-in. squares. About 50 g., selected at random, shall be accurately weighed and distilled with 100 cc. of a coal-tar distillate of which 5 to 10 per cent boils below 100° C. (212° F.) and of which at least 90 per cent distills up to 180° C. (356° F.) in an apparatus of the form and under the conditions prescribed in the Standard Method of Test for Water in Petroleum Products and Other Bituminous Materials (Serial Designation: D 95) of the American Society for Testing Materials.[1] The flask containing the solvent and sample shall be heated in a paraffin

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[1] 1924 Book of A.S.T.M. Standards.

bath at a temperature of 302 to 338° F. (150 to 170° C.) until no further water passes over. The distillate shall be allowed to stand in the graduated receiver until the water separates, whereupon the volume of water shall be measured and its weight calculated. From this, the average percentage of moisture in the fabric, as received, shall be calculated.

Strength. 12. (*a*) *Felted Fabrics.*—With a photographic trimmer having a stop attached exactly 1 in. behind the blade, ten strips shall be cut with the fiber grain, as shown at *B-1* to *B-10* (Fig. 1) and ten strips across the fiber grain as shown at *C-1* to *C-10*. Each strip should measure 6 in. and have parallel sides 1 in. apart (within $\frac{1}{32}$ in.) with the edges cut straight and clean. Both sets of strips shall be tested at 70° F. (21.1° C.), using a tension testing machine such as the Scott Strength Tester (Type F, 100 lb. capacity), the Perkins Strip Tester, or equal, in which the clamps are attached to swivels free to move in any direction. The test strips shall be gripped $1\frac{1}{2}$ in. on each end, leaving approximately 3 in. between the clamps. The tension shall be increased by causing the lower clamp of the machine to travel at a uniform speed of 12 in. per minute. If any strip breaks nearer than $\frac{1}{2}$ in. to either clamp, the reading shall be disregarded, and an additional strip shall be tested in its place. The ten readings, with and across the grain, respectively, shall be averaged for each roll sampled. From these results the average strength with and across the fiber grain, respectively, of the fabric as supplied, shall be calculated.

(*b*) *Woven Fabrics*—Woven fabrics shall be tested at 70° F. (21.1° C.) in accordance with the "grab test No. 2" as described in Section 12 (*b*) of the Standard Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

NOTE.—As a referee method, or in case any dispute arises regarding the strength, the test shall be repeated, with the exception that the fabric before testing shall be exposed at least two hours in an atmosphere of 65 per cent relative humidity at 70° F. (21.1° C.).

Pliability. 13. With the trimmer described in Section 12 (*a*), five 6-in. strips shall be cut with the fiber grain, as shown at *D-1* to *D-5* (Fig. 1) and immersed in water at 77° F. (25° C.) for from 10 to 15 minutes. These strips shall be bent through 180 deg. at a uniform speed, in exactly 2 seconds, around a mandrel, the diameter of which shall be as follows: The first, around a mandrel 25 mm. in diameter; the second, around a mandrel 20 mm. in diameter; the third, around a mandrel 15 mm. in diameter; the fourth, around a mandrel 10 mm. in diameter, and the fifth, around a mandrel 5 mm. in diameter. The test may also be made at 32° F. (0° C.). The pliability shall be expressed numerically from 1 to 10 as follows:

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[1] 1924 Book of A.S.T.M. Standards,

(1) Cracks entirely through the sheet on the 25-mm. mandrel.
(2) Cracks part way through the sheet on the 25-mm. mandrel.
(3) Cracks on the 25-mm. mandrel.
(4) Cracks on the 20-mm. mandrel.
(5) Cracks on the 15-mm. mandrel.
(6) Cracks on the 10-mm. mandrel.
(7) Cracks on the 5-mm. mandrel.
(8) Cracks when bent through 180 deg. over a $\frac{1}{16}$-in. (1.588-mm.) mandrel.
(9) May be bent through 180 deg. over a $\frac{1}{16}$-in. (1.588-mm.) mandrel in one direction without cracking, but will crack when bent through 360 deg. in the opposite direction.
(10) May be bent through 180 deg. over a $\frac{1}{16}$-in. (1.588-mm.) mandrel in one direction and then through 360 deg. over a $\frac{1}{16}$-in. (1.588-mm.) mandrel in the opposite direction without cracking.

The readings for each roll shall be averaged separately, and from these results the minimum, maximum and average pliability of the felt shall be calculated.

Water Absorbed.

14. (*a*) A section 18 in. square (as shown at *E*, Fig. 1) shall be cut from each specimen, weighed, and completely immersed in distilled water at 77° F. (25° C.) for 24 hours. The specimen shall then be removed and dried superficially by pressing lightly between two towels. As the moisture enters through the edges of the sheet more rapidly than through the surfaces, each specimen shall be trimmed to exactly 12 in. square, representing four-ninths of the original area, and reweighed rapidly. The increase in weight shall be calculated on the basis of the original test specimen by multiplying by $2\frac{1}{4}$. The percentage increase in weight represents the water absorption. The minimum, maximum and average for the shipment shall be calculated.

(*b*) Five strips shall be cut with the fiber grain as shown at *F 1* to *F 5* (Fig. 1); five other strips shall be cut across the fiber grain as shown at *G 1* to *G 5* (Fig. 1) and the strength shall be redetermined as in Section 12. The decrease in strength in percentage shall be calculated after the specimen has been subjected to water.

Loss on Heating.

15. (*a*) *Asphalt Saturated Products Only.*—From each specimen, 12 by 6-in. strips shall be cut at *K-1* and *K-2* in Fig. 1, care being taken

not to disturb any of the detached surfacing. Each strip shall be weighed and suspended in the center of an air oven maintained at 221° F. (105° C.) ± 5° F. (3° C.) with a thin wire fastened through holes punctured near one edge. The thermometer shall be inserted in the oven to such a depth that its bulb will be in line with the center of the specimens. The strips shall be kept in the oven for exactly 5 hours, then cooled and removed carefully, and each specimen weighed. The average loss shall be calculated as a percentage and the average percentage of moisture (ascertained in Section 11) deducted. The final figure shall represent the average loss on heating, exclusive of moisture.

Extraction of Saturant.

(*b*) *Coal-Tar Saturated Felt Only.*—From the rolls making up the sample, strips 6 in. wide shall be cut across the sheet. Sufficient of these shall be taken to make up a sample of 250 g. ± 5.0 g. These strips then shall be rolled up and placed in the wire basket of the extraction apparatus described in the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (Serial Designation: D 147 – 25 T) of the American Society for Testing Materials[1] or other extraction apparatus of suitable construction. The sample shall then be covered with a disk of soft filter paper to insure an even distribution of the solvent. The extraction shall be carried out as described in Methods D 147 – 25 T.

Recovery of Saturant from CS_2 Extract.

The CS_2 extract containing the bitumen shall be transferred to a 500-cc., short-neck, round-bottom flask. The flask shall be equipped with a Hempel column, 16 cm. in length, 15 mm. in inside diameter and filled to a depth of 5 cm. with glass beads. The Hempel column shall be connected with a water cooled condenser. A 0 – 80° C. thermometer as described in the Tentative Method of Float Test for Bituminous Materials (Serial Designation: D 139 – 25 T) of the American Society for Testing Materials[2] shall be placed in the Hempel column so that the top of the bulb shall be opposite the bottom of the tubulature. Distillation for the removal of CS_2 shall be continued by means of a steam bath until drops cease to fall from the condenser. The distillation then shall be carried out over a small flame, heating carefully and observing the thermometer until the distillation ceases and the temperature of the vapor as indicated by the thermometer shows no further rise on slightly increasing the flame.

Distillation of Saturant.

When the contents of the flask is sufficiently cool to be poured without appreciable vaporizing, 100 g. ± 0.1 g. shall be distilled in accordance with the method described in Sections 10, 11 and 12 of the Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials.[1]

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 786 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 772.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 748 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 586.

Fractions shall be taken at 210° C. and 235° C. and the distillation stopped at that point. The per cent of distillate by weight at each temperature shall be calculated on the basis of the weight of sample taken for distillation.

III. DESATURATING THE FABRIC.

Desaturated Fabric.

16. From each roll sampled, a 2-in. strip (within $\frac{1}{32}$ in.) shall be cut across the specimen as shown at *H* (Fig. 1). Each strip shall be extracted with carbon disulfide[2] in an extractor described in Section 4 of the Tentative Methods of Testing Bituminous Mastics, Grouts and Like Mixtures (Serial Designation: D 147 – 25 T) of the American Society for Testing Materials,[3] the extraction being continued for several hours after the drippings have become colorless. The desaturated fabric shall be removed and heated in a ventilated oven at 225° F. (107.1° C.), cooled in a desiccator, any adhering comminuted surfacing being brushed off and retained, and weighed as rapidly as possible. The heating shall be repeated until the weight of the fabric remains constant as determined by two consecutive weighings taken not less than ten minutes apart which shall show a further loss of not more than 0.1 per cent. This will give the weight of the fabric in the moisture-free state. Where a coal-tar pitch saturant has been used, the moisture-free weight of the desaturated fabric shall be corrected for the carbonaceous matter retained mechanically in its interstices, by means of the method described in Section 17.

Retained Carbonaceous Matter.

17. The following colorimetric method shall be used to ascertain the carbonaceous matter derived from a coal-tar pitch saturant and retained by the desaturated fabric:

(*a*) About 15 g. of an unsaturated fabric of the same general character as the one under examination, shall be macerated by boiling in water, disintegrating with a rotary egg-beater and picking the fibers apart with needles. The fibers shall be filtered through fine cloth and dried at a temperature of 225° F. (107.1° C.) to constant weight. One gram of the fibers shall be accurately weighed into a flask and diluted to exactly 100 cc. with distilled water at room temperature. About 50 g. of glass beads shall be added and the contents of the flask shaken vigorously until the fibers are reduced to a homogeneous pulp in uniform suspension.

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[1] 1924 Book of A.S.T.M. Standards.

[2] In this test, chloroform may be used as an equivalent solvent.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 786 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 772.

(*b*) A distilled coal-tar, having approximately 10 to 25 per cent of insoluble carbonaceous matter, shall be procured and the carbonaceous matter extracted with benzol until it is free from soluble matter; then dried at a temperature of 225° F. (107.1° C.) to constant weight. One gram of the purified carbonaceous matter shall be accurately weighed and diluted to exactly 100 cc. at room temperature with a starch solution of a consistency sufficient to carry the carbonaceous matter into temporary suspension. (A 12.5-per-cent solution is recommended.)

(*c*) The liquid carrying the fibers, obtained as described in Paragraph (*a*), shall be titrated with the suspension of carbonaceous matter, obtained as described in Paragraph (*b*), and from time to time a field prepared from a drop of the well agitated mixture shall be examined under a microscope at 100 diameters magnification until the color exactly matches a field prepared from the desaturated fabric under examination (obtained as described in Section 16), when both are viewed side by side under parallel conditions. The end-point is fairly sharply defined. The burette reading gives directly the percentage of carbonaceous matter adhering to the moisture-free fabric under examination.

(*d*) The weight of moisture-free fabric ascertained in Section 16 shall be corrected by deducting the weight of adhering carbonaceous matter.

Total Comminuted Surfacing.

18. The total comminuted surfacing plus any filler present in the bituminous saturant represents the sum of the detached comminuted surfacing (Section 9), the amount brushed off from the surface of the desaturated fabric (Section 16), plus the amount recovered upon evaporating and igniting the bituminous extract obtained in accordance with Section 16.

Bituminous Saturant.

19. The weight of bituminous saturant represents the difference between the weight of the original fabric (Section 7), and the sum of the weights of the moisture-free desaturated fabric (Sections 16 and 17), plus moisture (Section 11), plus the total comminuted surfacing and filler present (Section 18).

IV. EXAMINATION OF THE EXTRACTED FABRIC.

(*A*) *Woven Fabrics.*

Weight.

20. Woven fabrics shall be tested for weight and number of threads per in. in accordance with Sections 6 to 11, inclusive, of the Standard Methods of Testing Cotton Fabrics (Serial Designation: D 39) of the American Society for Testing Materials.[1]

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[1] 1924 Book of A.S.T.M. Standards.

(*B*) *Felted Fabrics.*

21. The weight in pounds per 480 sq. ft. of the desaturated felt (corrected for any carbonaceous matter present) for each specimen examined, shall be calculated separately from the formulas: **Weight.**

$$\text{“Number”} = \frac{\text{Weight of specimen in grams}}{\text{Area of specimen in square centimeters}} \times 983$$

or

$$\text{“Number”} = \frac{\text{Weight of specimen in grams}}{\text{Area of specimen in square inches}} \times 152$$

This represents the "number" of the moisture-free felt on the felt makers' scale. The minimum, maximum and average "number" of the felt in its moisture-free state shall be calculated. This may be corrected to the condition in which it actually existed in the material under examination, by adding thereto the percentage of moisture as determined in Section 11.

22. A representative sample shall be secured by cutting from each strip of desaturated felt a piece about ½ in. in diameter as shown at *I-1*, *I-2*, and *I-3* (Fig. 1). About 25 g. selected at random from all the specimens sampled in this manner shall be accurately weighed, and incinerated in a weighed porcelain or quartz crucible either over an open flame or in a muffle, until all the carbon is consumed. A few drops of ammonium carbonate solution shall be added, the sample ignited gently, and weighed. The percentage of ash shall be calculated on the basis of the moisture-free felt. **Ash.**

NOTE.—As a referee method, or in case greater accuracy is desired, the three portions taken from each specimen roll shall be weighed and ignited separately. The minimum, maximum and average of ash present shall be calculated on the basis of the moisture-free felt.

TENTATIVE METHODS OF TESTING ASPHALT ROLL-ROOFING SURFACED WITH FINE OR GRANULAR TALC, SLATE-SURFACED ASPHALT ROLL-ROOFING AND SLATE-SURFACED ASPHALT SHINGLES[1]

Serial Designation: D 228 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope. 1. These methods cover the examination of roofings and shingles composed of roofing-felt, saturated and coated on both sides with asphalt, and surfaced on the top with either powdered or granulated mineral matter, and on the under side with powdered mineral matter.

I. SAMPLING

Sampling. 2. From each shipment or portion thereof representing a product of the same kind, class and weight, a number of rolls or bundles shall be selected at random, equivalent to one-half the cube root of the total number of rolls or bundles included in the lot, except that in lots of 1000 or less, five rolls or bundles shall be taken. If the cube root, as calculated, proves to be a fractional number, it shall be expressed as the nearest higher whole number. For convenience, the following table is given, showing the number of samples to be selected from shipments of various sizes:

PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED	PACKAGES IN SHIPMENT	NUMBER OF PACKAGES SELECTED
Up to 1000..........	5	5 833 to 8 000........	10
1001 to 1728..........	6	8 001 to 10 648........	11
1729 to 2744..........	7	10 649 to 13 824........	12
2745 to 4096..........	8	13 825 to 17 576........	13
4097 to 5832..........	9	17 577 to 21 952........	14

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

II. DETERMINATION OF SIZE AND WEIGHT

(*A*) *Smooth-roll and Slate-roll Roofing*

3. Each roll selected shall be stripped. The wrappers, packing material, nails and cement taken from each roll shall be weighed together to the nearest $\frac{1}{4}$ lb. and the maximum weight thereof per roll shall be recorded. The quantity and character of nails and cement shall be recorded.

4. Each roll shall be unwound, discarding any detached surfacing that may fall off in so doing, and the workmanship and finish of the roofing observed.

5. The length and width of each roll shall be measured to the nearest $\frac{1}{4}$ in., and the square feet of material contained in each roll calculated. From this, the average area of the rolls examined shall be calculated.

6. The rolls shall be rewound, fastened with pieces of light string and then each roll shall be weighed to the nearest $\frac{1}{4}$ lb. The weight of roofing per 108 sq. ft. contained in each roll shall be calculated and the minimum weight per 108 sq. ft. recorded. This shall be regarded as the minimum weight per 108 sq. ft. of the entire shipment.

7. The average weight per 108 sq. ft. for the rolls examined shall be calculated. This shall be regarded as the average weight per 108 sq. ft. of the entire shipment.

8. From the rolls examined, the one whose weight per 108 sq. ft. is nearest the average weight of the lot shall be selected. The first convolution or two shall be unrolled, and with a knife and straight edge, the sheet shall be cut across at right angles to the edges. A section measuring exactly 30 in. in the direction of the roll's length shall then be removed. The width of this section shall be measured to the nearest $\frac{1}{32}$ in. and weighed with an accuracy of $\frac{1}{4}$ oz. The weight in pounds per 108 sq. ft. shall then be calculated from the following formula:

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of 30-in. section in ounces}}{\text{Width of 30-in. section in inches}} \times 32.4$$

This must check within 1 per cent of the average weight per 108 sq. ft. of the shipment (Section 7). If this sample fails to do this, then additional samples shall be cut from the same roll, until one is obtained which does, which sample shall be kept for further examination.

NOTE.—As a referee method, or in case any dispute arises regarding the properties as may be ascertained from the particular sample selected, a 30-in. sample shall be taken and examined separately from each roll sampled in Section 2.

(*B*) *Slate-surfaced Shingles*

9. Each bundle selected shall be stripped. The packing material shall be weighed to the nearest ¼ lb., recording the weight separately for each bundle. The maximum weight of packing material per "square" shall be recorded.

10. The shingles in each bundle, a, shall be counted, discarding any detached surfacing that may fall off in so doing. The workmanmanship and finish of the shingles shall be observed.

11. The shingles contained in each bundle shall be weighed to the nearest ¼ lb. (b). The dimensions of the shingles shall be accurately measured and the net area of material in each shingle calculated in square feet (c).

12. The area in square feet of material contained in each bundle ($a \times c$) shall be calculated. The weight of roofing material per 108 sq. ft. contained in each bundle $\left(\frac{b}{a \times c} \times 108\right)$ shall be calculated, and the minimum weight per 108 sq. ft. recorded. This shall be regarded as the minimum weight per 108 sq. ft. of the entire shipment.

13. The average weight (d) per 108 sq. ft. for the bundles examined shall be calculated. This shall be regarded as the average weight per 108 sq. ft. of the entire shipment. Also, the average weight per shingle $\left(\frac{c \times d}{108}\right)$ shall be calculated.

14. From the bundles selected, a definite number of representative shingles, whose weight shall fall within 1 per cent of the average weight ascertained in Section 13 shall be taken for further consideration. The number of shingles so selected shall represent as closely as possible 6 sq. ft. of material, and shall be selected as far as possible from different bundles.

NOTE.—As a referee method, or in case any dispute arises regarding the properties as may be ascertained from the particular sample selected, then a similar sample shall be taken and examined separately from each bundle of shingles sampled in Section 2.

III. DETERMINATION OF PLIABILITY OF SMOOTH-ROLL ROOFING AND SLATE-ROLL ROOFING

15. With a photographic trimmer five strips shall be cut from the sample of roofing, each 1 in. in width and 6 in. in length, in the direction of the fiber grain, and immersed in water at 77° F. (25° C.) for 10 to 15 minutes. These strips shall be removed from the water and

immediately bent through 180 deg. at uniform speed, in exactly 2 seconds, over a mandrel of the following size:

Smooth-roll Roofing—At least 3 of the 5 strips shall not crack over a mandrel 10 mm. in diameter.

Slate-roll Roofing—At least 3 of the 5 strips shall not crack on a mandrel 25 mm. in diameter.

IV. DETERMINATION OF BEHAVIOR ON HEATING

16. Two strips shall be cut from the sample of roofing or shingles, each approximately 8 by 8 in. They shall be weighed and suspended vertically in the center of an air-oven maintained at 176° F. (80° C.) ±5°F. (3° C.) with a thin wire fastened through holes punctured near one edge. The thermometer shall be inserted in the oven to such a depth that its bulb will be in line with the center of the specimens. The strips shall be maintained at the prescribed temperature for exactly two hours, then cooled, removed carefully and each specimen weighed. The average loss shall be calculated as a percentage. Any change in appearance of the specimen shall be recorded, such as flowing, sagging, blistering or absorption of the surface coatings; also sliding of granular surfacing.

V. DETERMINATION OF SATURANT IN MOISTURE-FREE FELT

17. Two strips shall be cut from the sample of roofing or shingles, each approximately 2 in. in width and 8 in. in length. They shall be warmed in an oven at a temperature of approximately 176° F. (80° C.). Then with a knife, the front and back coatings shall be peeled off, care being taken to remove as little as possible of the saturated felt, and to assure that all of the coatings and surfacing are stripped from the felt. The saturated felt so obtained shall be weighed. It shall be extracted with benzol, chloroform, carbon tetrachloride or carbon disulfide, in a suitable extractor and the extraction continued until the drippings have become colorless. The desaturated felt shall be removed from the extractor, placed in a tared vessel, heated in a ventilated oven at 225° F. (107° C.) for 30 minutes, cooled in a desiccator, and the felt finally weighed as rapidly as possible. The heating shall be repeated until the weight of the felt remains constant as determined by two consecutive weighings taken not less than 10 minutes apart, which shall show a further loss of not more than 0.1 per cent. From the weight so obtained and the original weight, the percentage of saturation carried by the moisture-free felt shall be computed.

VI. DETERMINATION OF WEIGHT OF MOISTURE-FREE FELT

18. Two strips shall be cut from the sample of roofing or shingles, each approximately 2 in. in width and 8 in. in length. Each of these shall be accurately weighed in grams and the length and width measured to within 1 mm. or $\frac{1}{32}$ in. It shall be extracted with carbon disulfide,[1] in a suitable extractor and the extraction continued until the drippings have become colorless. The desaturated felt shall be removed from the extractor, being careful not to lose any adhering mineral matter, placed in a tared vessel, heated in a ventilated oven at 225° F. (107° C.) for 30 minutes, cooled in a desiccator, any adhering surfacing material brushed off and retained and the felt finally weighed as rapidly as possible. The heating shall be repeated until the weight of the felt remains constant as determined by two consecutive weighings taken not less than 10 minutes apart, which shall show a further loss of not more than 0.1 per cent. The carbon disulfide extract and accompanying mineral matter shall be retained for further examination. From the weights so obtained and the respective areas of the strips of desaturated felt, the weight of moisture-free felt shall be computed in pounds per 108 sq. ft., from the following formulas and the results averaged:

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of moisture-free felt in grams}}{\text{Area of specimen in square centimeters}} \times 221.2$$

or

$$\text{Pounds per 108 sq. ft.} = \frac{\text{Weight of moisture-free felt in grams}}{\text{Area of specimen in square inches}} \times 34.3$$

VII. DETERMINATION OF ASH IN MOISTURE-FREE FELT

19. The strips of desaturated felt obtained as described in Section 18 shall be cut into squares about 2 cm. on each side and thoroughly mixed. Pieces amounting to about 10 g. shall be selected at random and dried at 225° F. (107° C.) for 30 minutes. They shall be cooled in a desiccator, accurately weighed and then incinerated in a weighed crucible either over an open flame or in a muffle until all the carbon is consumed. A few drops of ammonium carbonate solution shall then be added, the sample ignited gently and weighed. The percentage of ash shall be calculated on the basis of the moisture-free felt.

VIII. DETERMINATION OF MINERAL SURFACING AND MINERAL MATTER IN COATINGS

20. (*a*) The slate and other mineral matter recovered from the extraction process described in Section 18 shall be combined with the mineral matter removed from the surface of the desaturated felt and

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[1] In this test, chloroform may be used as an equivalent solvent.

that resulting from the evaporation and ignition of the carbon disulfide extract. The mineral matter shall be dried in air free from the odor of carbon disulfide, then heated in an oven for 30 minutes at 225° F. (107° C.), and finally cooled in a desiccator and weighed. From the combined weight of the specimens taken in Section 18, the total 'mineral surfacing and mineral matter in the coatings" shall be calculated in pounds per 108 sq. ft.

(*b*) For asphalt roll-roofing surfaced with granular talc, the mineral matter recovered as described in Paragraph (*a*) shall be washed through a 65-mesh copper wire screen with three washings of water of 100 cc. each. The total aqueous suspension of mineral matter which passes through the screen shall then be filtered through a weighed gooch crucible. It shall then be dried at 225° F. (107° C.) and reweighed. The difference in weight represents the mineral matter passing a 65-mesh screen which shall be converted into pounds per 108 sq. ft.

TENTATIVE METHOD OF TEST
FOR
STEAM DISTILLATION OF BITUMINOUS PROTECTIVE COATINGS[1]

Serial Designation: D 255 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

Scope. 1. This is a general method for the separation and recovery of the solvent and the base in bituminous mixtures.

Description. 2. The bituminous mixture is distilled in a current of steam, the solvent is condensed and separated from the water.

I. APPARATUS

Steam Generator. 3. The steam generator shall be made of either metal or glass, with a capacity of from 2 to 4 liters, suitable for continued use in the production of steam. If of glass, it shall be fitted with two outlets with suitable connections for rubber tubing. In the case of a metal generator, a large opening for filling and a water gage shall be additional parts of the apparatus. The generator shall be supplied with suitable pinch cocks or valves so that steam may be blown off to the atmosphere until the test is ready.

Bath. 4. The bath shall be of metal of sufficient capacity to permit immersion of the distilling flask to a depth of not less than 10 cm.

Source of Heat. 5. Heat for the steam generator shall be supplied by a suitable gas generator or electric hot plate. The bath may be heated by any convenient means.

Distilling Flask. 6. The distilling flask shall be a short ring neck, round-bottom flask of 1000 cc. capacity. It shall be fitted with a three-hole rubber stopper; with a steam distilling tube which will reach to within $\frac{1}{2}$ in. (12.7 mm.) of the bottom of the flask and project from the top at a convenient distance for connection to the generator; a vapor outlet tube which extends from beneath the rubber stopper to a point sufficiently above the distilling flask that will permit convenient connection to the condenser; and with a thermometer. The steam tubing should be not less than 2 nor more than 4 mm. in internal diameter and the vapor outlet tube should be not less than 5 mm. in internal diameter.

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[1] Criticisms of this Tentative Method are solicited, and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-8 on Bituminous Waterproofing and Roofing Materials, 441 Lexington Ave., New York City.

Condenser. 7. The condenser shall consist of a $\frac{9}{16}$-in. (14.29-mm.) outside diameter No. 20 Stubbs Gage seamless brass tube, 22 in. (55.88 cm.) long. It shall be set at an angle of 75 deg. from the perpendicular and be surrounded with a cooling bath 15 in. (38.1 cm.) long, approximately 4 in. (10.16 cm.) wide by 6 in. (15.24 cm.) high. The lower end of the condenser tube shall be cut off at an acute angle, and curved downward for a length of 3 in. (7.62 cm.) and slightly backward so as to insure contact with the wall of the graduate at a point 1 to $1\frac{1}{4}$ in. (2.54 to 3.8 cm.) below the top of the graduate when it is in position to receive the distillate.

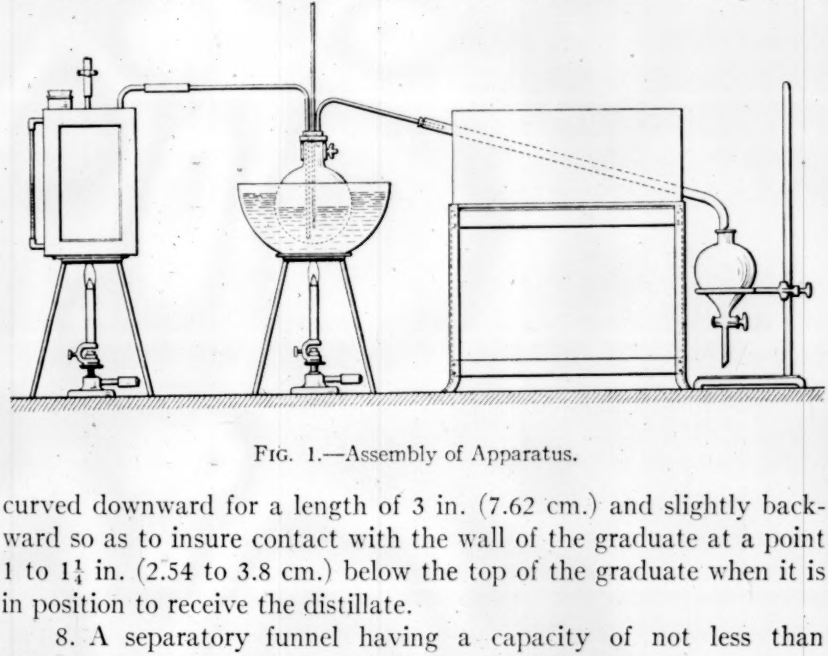

FIG. 1.—Assembly of Apparatus.

Separatory Funnel. 8. A separatory funnel having a capacity of not less than 500 cc., as shown in Fig. 1, should be provided.

Accessories. 9. (*a*) Accessories consist of suitable ring stands for supporting the steam generator, distilling flask, bath for distilling flask and separatory funnel.

(*b*) The A.S.T.M. Low-Distillation Thermometer for the distillation flask, conforming to the requirements specified in Section 6 (*a*) of the Tentative Method of Test for Distillation of Gasoline, Naphtha, Kerosine and Similar Petroleum Products (Serial Designation: D 86 – 26 T) of the American Society for Testing Materials,[1] shall be used.

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[1] See p. 816.

II. PROCEDURE

Preparation. 10. The apparatus shall be assembled as shown in Fig. 1. The steam generator shall be filled with water and heat applied. The bath shall be filled with a high-flash-point oil and raised to approximately 140° C. (284° F.) Five hundred cubic centimeters of the sample shall be weighed into the round-bottom flask. The connection shall be made from the steam distillate to the steam delivery tube, the end of which shall be within ½ in. of the bottom of the distilling flask. The outlet from the distilling flask shall be connected to the condenser and the separatory funnel placed in position at the outlet of the condenser to receive the distillate. The end of the bulb of the thermometer in the steam distilling flask shall be placed within ½ in. (12.7 mm.) of the bottom of the distilling flask.

When the temperature of the sample in the distilling flask reaches 130° C. the outlet of the steam generator shall be closed, thus forcing the steam to pass through the sample. The flow of steam shall be adjusted so that the distillate is collected at the rate of approximately 6 to 10 cc. per minute.

The distillation shall be stopped when 100 cc. of the distillate contains not more than 0.5 cc. of solvent as determined by measuring the amount of oil in 100 cc. of distillate.

When the distillation is finished, the water shall be separated from the distillate and the distillate measured and retained for further tests if required by the specifications.

In some cases, the distillate does not separate readily from the water, and this separation can be facilitated by the addition of sodium chloride which will result in a sufficient difference in gravity to produce a clear separation of the two layers.

The results shall be reported in per cent by weight or volume as required by the specifications, based on the weight of the sample taken.

TENTATIVE DEFINITION OF THE TERM SLATE[1]

Serial Designation: D 247 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

Slate.—A microgranular crystallin stone derived from argillaceous sediments by regional metamorphism, and characterized by a perfect cleavage quite independent of original bedding, which has been induced by pressure within the earth.

Note 1.—The essential mineral constituents are white mica (chiefly sericite) and quartz. Prominent accessory constituents are black mica (biotite), chlorite and hematite. Minor accessory constituents are carbonates, magnetite, apatite, clay, andalusite, barite, rutile, purite, graphite, feldspar, zircon, tourmaline and carbonaceous matter.

Note 2.—Igneous slates because of their rare occurrence and insignificant commercial importance are not covered in this definition.

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[1] Criticisms of this Tentative Definition are solicited and should be directed to Mr. D. K. Boyd, Secretary of Committee D-16 on Slate, Structural Service Bureau, Otis Building, Philadelphia, Pa.

TENTATIVE METHODS OF TESTING INSULATING VARNISHES[1]

Serial Designation: D 115 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1923, 1924, 1925, 1926.

Material Covered. 1. These tests are intended for varnishes which are applied by brushing, dipping or spraying, and are primarily for the purpose of providing electrical insulation.

I. SPECIFIC GRAVITY.

Specific Gravity. 2. The specific gravity shall be measured with a pyknometer, Westphal balance or with a hydrometer so graduated that the specific gravity can be determined to 0.001. The temperature of the varnish shall be not less than 18° C. (64.4° F.) nor more than 22° C. (71.6° F.) and corrected to 20° C. (68° F.) by applying a correction of 0.0007 per 1° C. (0.0004 per 1° F.).

II. VISCOSITY.

Viscosity. 3. The viscosity shall be determined at 20° C. (68° F.) and the results shall be stated in terms of absolute viscosity — poise[2] or centipoise (centipoise = 0.01 poise).

NOTE 1.—When measurements are made by an indirect method, the instrument used must be standardized. Oils of standard viscosity for use in standardizing such instruments can be obtained from the U. S. Bureau of Standards.

NOTE 2.—A description of the MacMichael viscosimeter as remodeled and improved for varnish testing may be obtained from the secretary of Committee D-9 together with directions for its calibration in absolute units.

III. FLASH POINT.

Procedure for Flash Point. 4. The flash point shall be determined in accordance with the Standard Method of Test for Flash Point of Volatile Flammable Liquids

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

[2] The absolute viscosity of a material or its viscosity in absolute units (c.g.s., poises) has been defined as the force in dynes required to move, at a velocity of 1 cm. per second, one surface having an area of 1 sq. cm. past another parallel like surface 1 cm. away, overcoming the resistance to shear of the material filling the space between.

(Serial Designation: D 56) of the American Society for Testing Materials.[1]

IV. TIME OF DRYING.

Test Specimen.

5. (*a*) Specimens for this test shall be pieces of thoroughly cleaned, smooth sheet copper or brass about 3 cm. (1.18 in.) wide and 20 cm. (7.88 in.) long and about 0.127 mm. (0.005 in.) thick.

(*b*) The specimen shall be dipped once in the varnish at a room temperature of approximately 20° C. (68° F.) and withdrawn slowly and uniformly (about 38 cm. (15 in.) per minute). The consistency of the varnish shall be first so adjusted by trial that, when dry as determined in accordance with Section 7, the thickness of the film of varnish on each side of the metal shall be between 0.022 mm. (0.0009 in.) and 0.026 mm. (0.001 in.). Care shall be taken before dipping the specimens that the varnish has stood in the dipping tank for a sufficient length of time to be free from air bubbles.

Procedure.

6. (*a*) Specimens of air-drying varnish shall be dried in dust-free air at a room temperature of approximately 20° C. (68° F.).

(*b*) In the case of baking varnishes, six specimens shall be dipped and allowed to drain at a room temperature of approximately 20° C. (68° F.) until the varnish is set as indicated when the impression left on the surface by pressing lightly thereon with a finger will not become obliterated by further flow of the material. They are then to be dried in dust-free air in an oven at 105 to 110° C. (221 to 230° F.). At the end of the first 30 minutes, and again at the end of each 10-minute period thereafter, one specimen shall be taken from the oven and examined. In the case of slow-drying varnishes, this 10-minute period may be lengthened at the discretion of the operator.

Time of Drying.

7. The varnish shall be considered dry when a specimen will not stick to itself when folded and pressed together between the thumb and finger at a temperature of approximately 20° C. (68° F.).

V. DIELECTRIC STRENGTH TEST.

Dielectric Strength Test Specimen.

8. (*a*) Specimens for the dielectric strength test shall be prepared by dipping pieces of kraft paper about 20 cm. (7.88 in.) square and about 0.076 mm. (0.003 in.) thick into the varnish which shall be at the consistency prescribed in Section 5 (*b*).

NOTE.—The paper used shall be that which is commercially known as No. 1 Sulfate Kraft. The surface of the paper shall be smooth, free from pimples or lumps and reasonably free from hairy fibers. The paper shall also be free from conducting particles, slime spots, creases, cuts, specks or other "paper defects."

(*b*) Each specimen shall be dipped twice, as specified in Section 5 (*b*), once in each direction, in order to give a more uniform thickness of coating. The specimen shall be dried after each dip in the same vertical position in which it was dipped.

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[1] 1924 Book of A.S.T.M. Standards.

(*c*) Specimens of air-drying varnish shall be dried in dust-free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period 600 per cent longer than that determined in accordance with Section 7, provided such period does not exceed 24 hours.

(*d*) Specimens of baking varnish shall be drained and then baked in dust-free air after each dip for a period 300 per cent greater than that determined in accordance with Section 7 provided such period does not exceed 24 hours.

(*e*) The final thickness of the specimen shall be 0.152 mm. (0.006 in.) to within ± 15 per cent.

Procedure. 9. (*a*) The dielectric strength of the specimen shall be determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage shall be increased uniformly to breakdown at a rate of 0.5 kilovolt per second, except that if breakdown occurs at this rate in less than 40 seconds, the rate shall be decreased so that breakdown will occur in not less than 40 seconds. If the material fails at less than 5 kilovolts, the minimum time shall be reduced from 40 seconds to 20 seconds. Ten such punctures are to be made at various points selected at random on each specimen. In each test the thickness of the specimen is to be determined as close to the point of puncture as practicable.

NOTE.—When necessary, in order to get ten punctures, additional specimens should be tested.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined, and the voltage shall be measured by methods approved by the American Institute of Electrical Engineers.[1]

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 500 volts. The apparatus shall comply with the Standards of the American Institute of Electrical Engineers.

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[1] Standards of the American Institute of Electrical Engineers.

Dielectric Strength. 10. The volts at puncture, the thickness of the specimen and the volts per mil of thickness shall be reported for each of the ten tests, together with the average, maximum and minimum volts per mil.

NOTE.—This test is relative only, but it gives more uniform results than those obtained with a copper base. See the Appendix for a procedure for determining the dielectric strength on a copper base.

VI. WATER ABSORPTION TEST.

Procedure. 11. Specimens similar to those described in Section 8 shall be immersed in water at a room temperature of approximately 20° C. (68° F.) for a period of 24 hours. Upon removal from the water, the surface water shall be wiped off and dielectric strength tests made immediately as described in Section 9.

Dielectric Strength. 12. The volts at puncture, the thickness of the specimen and the volts per mil of thickness shall be reported for each of the ten tests, together with the average, maximum and minimum volts per mil.

VII. HEAT ENDURANCE TEST.

Test Specimens. 13. (*a*) For the heat endurance test, specimens shall be prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which shall be at the consistency prescribed in Section 5 (*b*).

(*b*) The specimens shall be dipped twice as prescribed in Section 5 (*b*).

(*c*) After removing not less than 1.27 cm. (0.5 in.) from one edge of the specimens the number of strips required by Section 14 (*a*) shall be cut from the same edge each 1.9 cm. (0.75 in.) in width.

Procedure. 14. (*a*) After setting as show by the test indicated in Section 6 (*b*), the strips referred to in Section 13 shall be placed in a uniformly heated oven in which the temperature is maintained at 100° C. (212° F.) within ± 5° C. (9° F.). A strip shall be removed at the end of 1, 2, 4, 8 and 24 hours respectively and every 24 hours thereafter. These, together with the initial strip, shall be tested as follows at a room temperature of approximately 20° C. (68° F.).

(*b*) Each strip shall be bent through 180 deg. over a rod 0.32 cm. ($\frac{1}{8}$ in.) in diameter. The number of hours of baking at which first cracking in the insulation occurs shall be noted and reported.

VIII. ACID AND ALKALI PROOF TEST.

Test Specimens. 15. The specimens to be used for the test for acid and alkali proofness shall be brass rods 1.5 cm. (0.59 in.) in diameter, 15 cm.

(5.90 in.) long and carefully rounded at one end to a radius of 0.75 cm. (0.295 in.). These specimens shall be dipped three times into the varnish, leaving exposed about 3 cm. (1.18 in.) of the rod at the end opposite the rounded end. Each coat shall be dried 25 per cent longer than the period determined in Section 7. Three specimens each shall be prepared for the acid and alkali solutions.

Procedure.

16. (*a*) The three specimens shall be suspended in the acid or alkali whose effect it is desired to determine to within 3 cm. (1.18 in.) of the end of the coated portion of the rod and suitable provision made for detecting the change in the electrical resistance between the rod and the solution. (Note 1.)

(*b*) It is recommended that these tests be made in 10-per-cent solutions as follows:

Sulfuric acid of sp. gr. 1.069 at 60° F. (15.5° C.) or nitric acid of sp. gr. 1.056 at 60° F. (15.5°) C.) or hydrochloric acid of sp. gr. 1.050 at 60° F. (15.5° C.) and sodium hydroxide of sp. gr. 1.115 at 60° F. (15.5° C.).

(*c*) The temperature of the solution shall be kept at approximately 20° C. (68° F.).

NOTE 1. A simple method is to connect a voltmeter between each rod in turn and one side of a 110 volt direct current circuit, the other side of the circuit being connected to the solution through any piece of suitable metal suspended in the solution. The resistance will be inversely proportional to the deflection of the voltmeter pointer, that is, the smaller the deflection, the greater the resistance. Failure of the material will, therefore, be indicated by a sudden increase in the deflection of the voltmeter pointer.

Acid and Alkali Proofness.

17. The resistance between each rod and the solution shall be measured once per day and the number of days elapsing before breakdown occurs shall be taken as the "proofness" of the varnish.

IX. OIL PROOF TEST.

Oil Test Specimen.

18. (*a*) To test for the effect of oil, the specimens shall be prepared as prescribed in Section 13 (*a*).

(*b*) The specimens shall be dipped and dried as prescribed in Sections 8 (*b*), (*c*) and (*d*).

(*c*) Test pieces shall be cut from the specimens as prescribed in Section 13 (*c*).

Procedure.

19. The effect of oil on the varnish shall be determined by immersing the specimens in transformer oil at a temperature of 100° C. (212° F.) for 48 hours and noting the effect on the varnish as indicated, for example, by wiping with a piece of dry white cloth.

NOTE.—Incipient disintegration of the surface of the varnish may sometimes be detected by examining the oil for turbidity. If a specimen of the oil filtered through filter paper can be distinguished from an unfiltered sample when the two samples are held in front of a strong light, the oil is turbid.

X. DRAINING TEST.

(ALSO KNOWN AS "WORKING VISCOSITY" TEST)

Test Specimen. 20. A strip of bond paper 0.064 mm. (2.5 mils) in thickness, 10.2 cm. (4 in.) in width and 50.8 cm. (20 in.) in length, shall be immersed in the varnish at a room temperature of approximately 20° C. (68° F.) up to a line previously drawn across the paper a few inches from the top. The paper shall be withdrawn at a slow and uniform rate (about 38 cm. (15 in.) per minute), care being taken that the varnish is free from air bubbles. The specimen shall be permitted to drain thoroughly at room temperature while suspended in a vertical position. It shall then be dried or baked (according to the type of the varnish) until dry as determined in accordance with Section 7.

Measurements. 21. The thickness of the specimen in mils shall be measured at points 5.1 cm. (2 in.), 17.8 cm. (7 in.) and 30.5 cm. (12 in.), respectively, from the line to which the specimen was immersed.

Report. 22. The thickness of each film in mils at the three points specified in Section 21 shall be recorded. The difference between the thickness at the upper point (5.1 cm.) and that at the lower point (30.5 cm.) shall be taken as a measure of the variation in the film thickness caused by draining.

XI. EVAPORATION TEST.

Procedure. 23. One hundred cubic centimeters of the varnish shall be placed in a flat-bottom crystallizing dish approximately 75 mm. (2.95 in.) in diameter and 45 mm. (1.77 in.) in height. It shall be heated to a temperature of 100° F. (37.8° C.) ± 2° F. (1.1° C.) for a period of 7 hours, the sample being exposed to still air in the open room.

Evaporation. 24. The decrease in volume of the sample shall be taken as the evaporation, this decrease being determined by noting the amount of water or kerosene that must be added to fill the dish to the original level.

NOTE.—This test is relative only. That is, it is only suitable for comparing one varnish with another when the tests are made simultaneously under exactly the same conditions.

XII. TEST FOR NON-VOLATILE MATTER.

Procedure. 25. A portion of the sample shall be placed in a stoppered bottle or weighing pipette and weighed. About 1.5 g. of the sample shall be transferred to a weighed flat-bottom metal dish about 8 cm. (3.15 in.) in diameter, such as the cover of a friction-top tin can. The container shall again be weighed and the exact weight of the portion of the sample transferred to the weighed dish calculated by difference. The dish with its contents shall be heated for three hours in an oven maintained at 105 to 110° C. It shall then be weighed after cooling.

Non-Volatile Matter.

26. The ratio of the weight of the residue to that of the original sample expressed as a percentage shall be taken as the percentage of non-volatile matter in the varnish.

APPENDIX

Where it is desired to make dielectric strength tests of solid films of varnish (as distinguished from the specimens prescribed in the methods, which are a combination of varnish and paper fibers), it is recommended that copper be used as the base as formerly required in the methods. The following are the directions for preparing and testing such specimens:

1. (*a*) Specimens are prepared by dipping pieces of thoroughly cleaned, smooth sheet copper or brass about 20 cm. (7.88 in.) square and about 0.127 mm. (0.005 in.) thick into the varnish which is at the consistency prescribed in Section 5 (*b*) of the methods.

(*b*) Each specimen is dipped twice, once in each direction, in order to give a more uniform thickness of coating. The specimen is dried after each dip in the same vertical position in which it was dipped.

(*c*) Specimens of air-drying varnish are dried in free air after each dip at a room temperature of approximately 20° C. (68° F.) for a period 600 per cent longer than that determined in accordance with Section 7 of the methods provided such period does not exceed 24 hours.

(*d*) Specimens of baking varnish are drained and then baked after each dip for a period 300 per cent greater than that determined in accordance with Section 7 provided such period does not exceed 24 hours.

(*e*) The final thickness of the film of varnish on each side of the specimen is between 0.044 mm. (0.0018 in.) and 0.052 mm. (0.002 in.).

2. (*a*) The dielectric strength of the two films of varnish is determined by applying alternating potential to two circular metal disks, 5.08 cm. (2.0 in.) in diameter and with edges rounded to a radius of 0.64 cm. (0.25 in.) which are placed in contact with the two sides of the specimen directly opposite each other and under a pressure of approximately 0.5 kg. (1.1 lb.). Starting at zero, the voltage is increased uniformly to breakdown at a rate of 0.5 kv. per second, except that if breakdown occurs at this rate in less than 40 seconds, the rate shall be decreased so that breakdown will not occur in less than 40 seconds. Ten such punctures are to be made at various points selected at random on each specimen. In each test the thickness of the films of varnish is to be determined as close to the point of puncture as practicable.

NOTE.—When necessary, in order to get ten punctures, additional specimens should be tested.

(*b*) The frequency of the test potential shall be not greater than 100 cycles per second, and each part of the testing apparatus shall have a continuous rating of not less than 2 kva. (preferably larger). The wave form shall be a sine curve as defined, and the voltage shall be measured by methods approved by the American Institute of Electrical Engineers.

(*c*) The voltage may be controlled by any approved method which does not distort the wave form beyond the limits prescribed above and which does not subdivide the voltage in steps greater than 500 volts. The apparatus shall comply with the Standards of the American Institute of Electrical Engineers.

3. The volts at puncture, the net thickness of insulation and the volts per mil of net thickness shall be reported for each of the ten tests together with the average maximum and minimum volts per mil.

TENTATIVE METHODS OF TESTING ELECTRICAL PORCELAIN[1]

Serial Designation: D 116 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1924, 1926.

Material Covered. 1. These tests are intended to apply to porcelain which is to be used for electrical insulating purposes.

I. TENSILE STRENGTH

Apparatus. 2. Any standard testing machine of suitable capacity may be used providing the error in the loading range does not exceed 1 per cent.

Test Specimens. 3. (*a*) The test specimens for this test shall be of the form and dimensions shown in Fig. 1.

(*b*) For wet-process porcelain, the test specimens shall be made from a column obtained by forcing the batch mixture through a die. Sections of the column, after thorough drying, shall be formed to the required shape with due allowance for shrinkage. During the firing, care shall be taken to maintain the axis perfectly straight.

(*c*) For cast porcelain, the specimens shall be cast in molds of calcined gypsum (plaster of Paris) having the required shape, due allowance being made for all shrinkages. None of the material except the fins shall be removed from the specimen.

(*d*) For dry-process porcelain, the specimens shall be formed by pressure into the required shape in metal molds with due allowance for all shrinkages.

Mounting of Specimens. 4. (*a*) Suitable grips for holding the specimen shall be self-aligning and shall grip the specimen over sufficient area and in a manner not to cause pinching near the minimum section nor local compression at the smaller ends of the metal grips. Grips designed for the purpose and found satisfactory are shown in Fig. 2. In principle they are arranged like gimbals or a universal joint used for maintaining a mariner's compass in position. A yoke allows a ring to swing about

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

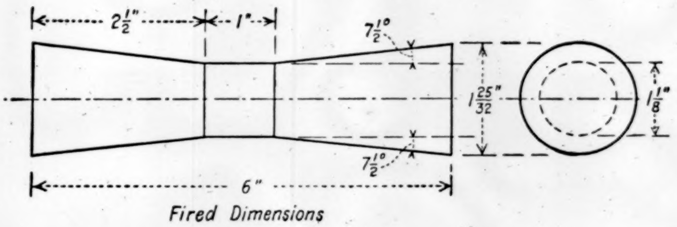
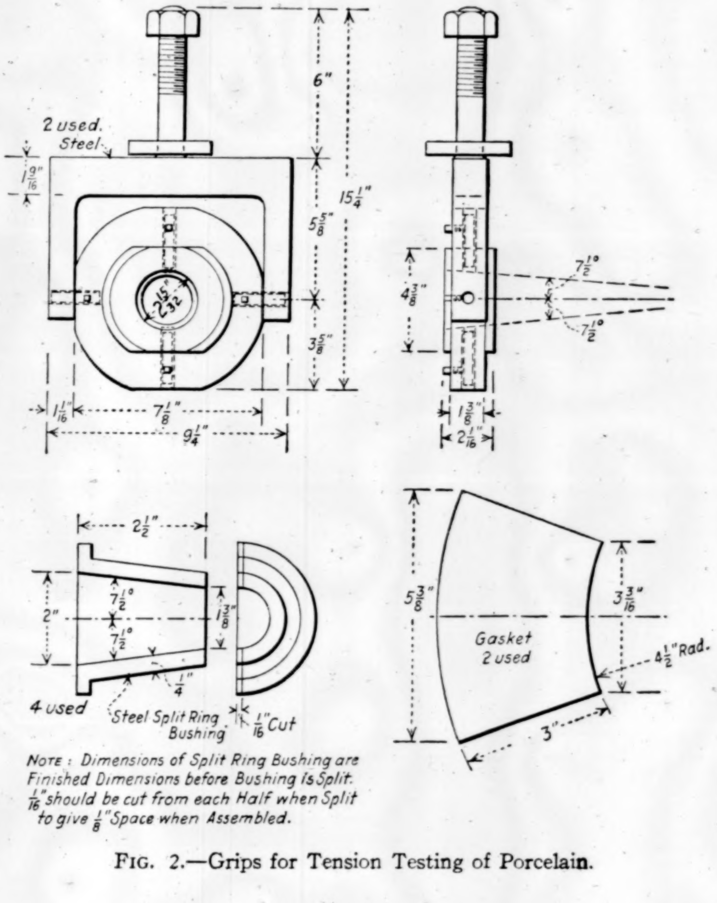

2½"
1"
7½°
1 25/32"
1⅛"
7½°
6"
Fired Dimensions

FIG. 1.—Test Specimen for Determining Tensile Strength of Porcelain.


2 used.
Steel
1 9/16"
6"
15¼"
5⅝"
2 15/32"
3⅜"
1 1/16"
7⅛"
9¼"
4⅜"
7½°
7½°
1⅜"
2 1/16"
2½"
2"
7½°
7½°
1⅜"
¼"
4 used
Steel Split Ring Bushing
1/16" Cut
5⅜"
3 3/16"
Gasket 2 used
4½" Rad.
3"

NOTE: Dimensions of Split Ring Bushing are Finished Dimensions before Bushing is Split. 1/16" should be cut from each Half when Split to give ⅛" Space when Assembled.

FIG. 2.—Grips for Tension Testing of Porcelain.

a horizontal axis. A smaller ring is situated inside the first one but pivoted by means of pins in a plane perpendicular to the horizontal axis. The inner ring is conically shaped and holds the porcelain specimen in place with the aid of the split bushings. The two yokes are placed in the testing machine at right angles to each other.

(*b*) The test specimen shall be fitted with a compressible gasket around each conical end with the parallel edges nearly touching. Blotting paper or sheet lead $\frac{1}{32}$ in. thick has been found satisfactory. The gasket may be held in place, while assembling the test specimen in the grips, by a temporary clamp at the place of minimum section. After the specimen has been assembled in place ready for test, the temporary clamp shall be removed. The grips holding the test specimen in place in the testing machine are shown in Fig. 3. A disassembled view of the apparatus is shown in Fig. 4.

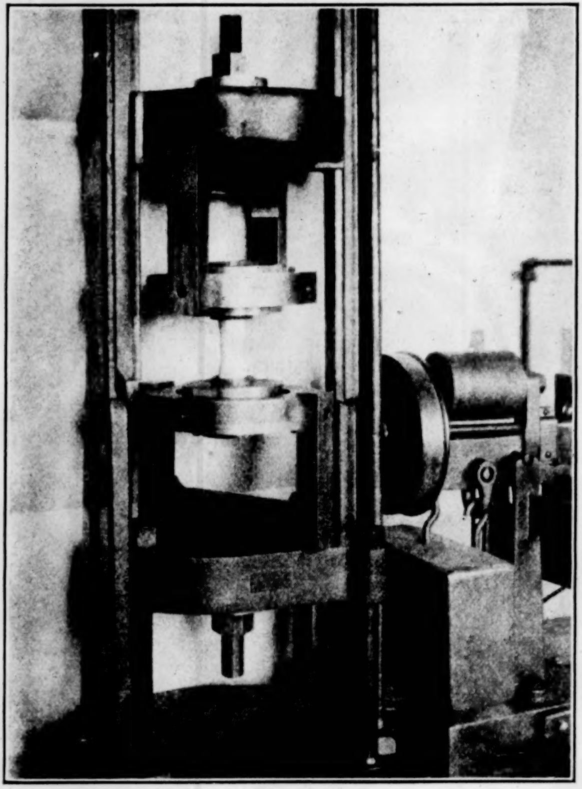


FIG. 3.—Grips and Test Specimens Assembled in Testing Machine in Tension Testing of Porcelain.

Procedure.

5. (*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) The diameter of each specimen at the minimum section shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculation shall be the average of two measurements taken at right angles.

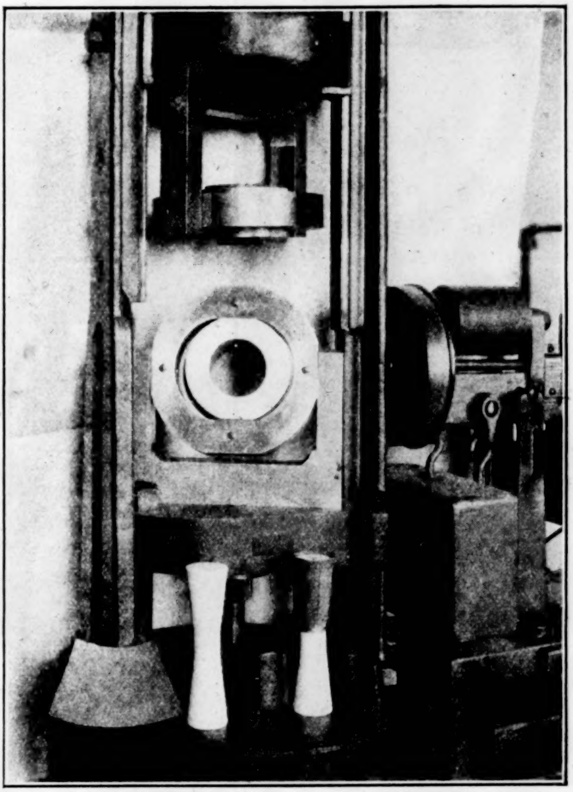


FIG. 4.—Apparatus for Tension Testing of Porcelain, Including Grips, Specimen, Split Ring and Blotting Paper Gasket.

(*c*) The speed of head of the testing machine shall be such that the load can be accurately weighed.

(*d*) The tests shall be made at a temperature of about 21° C. (70° F.).

(*e*) Results on specimens which do not break in the section of minimum cross-section shall be included, though the unit stress shall be calculated using the minimum cross-section. Any results whose deviation from the mean of the deviations is more than 3 times the mean of the deviations shall be discarded.

Report. 6. The report shall include the following:

(*a*) The breaking load of each specimen in pounds.

(*b*) The diameter of each specimen in inches at the place of break and at the minimum section.

(*c*) The tensile strength of each specimen in pounds per square inch.

(*d*) The average of the results given in Paragraph (*c*) and the percentage average deviation from the mean.

(*e*) A description of each fracture and the behavior of the material under load. The description of the fracture should tell whether the fractured area was totally or partially rough, and whether pin holes or other flaws were found.

NOTE.—An examination of the fracture of a normal specimen will show the entire area to consist of a very coarse granular surface, indicating that the entire area was subjected to tension and that the entire surface resisted it. In a specimen containing a pin hole or other flaw, the fracture will usually start near that flaw or pass through it. Part of the surface further away from the flaw will be granular, but the surface near the flaw will be much smoother. If the specimen is compressed at a narrow portion near one of the grips, the surface is again divided into two distinct areas, the area of tension and the area of shear, the latter radiating from the spot which was most under compression.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the tensile strength in pounds per square inch of each specimen, the first value being the lowest and each succeeding one the next higher.

II. COMPRESSIVE (CRUSHING) STRENGTH

Apparatus. 7. Any standard testing machine of suitable capacity may be used providing the error in the loading range does not exceed 1 per cent.

Test Specimens. 8. (*a*) The test specimens for this test shall be in the form of cylinders and shall be 1.125 in. (2.86 cm.) in length and 1.125 in. (2.86 cm.) in diameter.

(*b*) They shall be made as described in Section 3. The flat surfaces shall be made as smooth and parallel as possible before firing. After firing, the flat surfaces shall be ground smooth and parallel.

Procedure. 9. (*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) A contact pad or cushion of blotting paper $\frac{1}{64}$ in. thick shall be placed between the upper and lower faces of the specimen and the self-aligning heads of the testing machine to equalize irregularities in the surfaces. Fresh cushions shall be used for each specimen.

(*c*) The diameter and length of each specimen shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculations shall be the average of two measurements taken at right angles.

(*d*) The speed of head of the testing machine shall be such that the load can be accurately weighed.

(*e*) The tests shall be made at a temperature of about 21° C. (70° F.).

Initial and Ultimate Failure.

10. Note shall be made of the load in pounds at initial failure but the value of the load in pounds at ultimate failure shall be determined and used in calculating the compressive (crushing) strength.

Report.

11. The report shall include the following:

(*a*) The load in pounds on each specimen at initial failure and the load in pounds at ultimate failure.

(*b*) The diameter and length of each specimen in inches.

(*c*) The compressive (crushing) strength of each specimen in pounds per square inch.

(*d*) The average of the results given in Paragraph (*c*) and the percentage average deviation from the mean.

(*e*) The behavior of the material under load.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the compressive strength in pounds per square inch of each specimen, the first value being the lowest and each succeeding one the next higher.

III. TRANSVERSE STRENGTH

Apparatus.

12. Any standard testing machine of suitable capacity may be used.

Test Specimens.

13. (*a*) The test specimens for the transverse strength test shall be in the form of cylinders and shall be 6 in. (15.2 cm.) in length and 1.125 in. (2.86 cm.) in diameter.

(*b*) They shall be made as described in Section 3.

Mounting of Specimens.

14. The specimen shall be supported on two steel wedge-shaped blocks with supporting edge rounded to 0.125 in. (3.175 mm.) radius. The supports shall be 5 in. (127 mm.) apart and the specimen shall be laid upon them with $\frac{1}{2}$ in. (12.7 mm.) overlap at each end. The load shall be applied on top of the specimen at right angles to the specimen and midway between the supports by means of a wedge-shaped pressure piece (angle 45 deg.), the edge of which is rounded on a 0.125 in. (3.175 mm.) radius.

Method. 15. (*a*) Not less than five specimens shall be tested in the normal condition.

(*b*) The diameter of each specimen shall be measured with a micrometer graduated to 0.001 in. (0.025 mm.). The value of the diameter to be used in the calculations shall be the average of two measurements taken at right angles at the middle of the specimen.

(*c*) The load shall be applied at that constant rate of speed which will permit the beam to be kept well balanced at all loads.

(*d*) The tests shall be made at a temperature of about 21° C. (70° F.).

Modulus of Rupture. 16. The modulus of rupture shall be calculated for each specimen as follows:

$$M = \frac{8\,PL}{\pi\,d^3}$$

where M = modulus of rupture;
P = load in pounds at rupture;
L = distance between supports in inches;
d = diameter of specimen in inches;
π = 3.1416.

Report. 17. The report shall include the following:

(*a*) The breaking load of each specimen in pounds.

(*b*) The diameter and length of each specimen in inches.

(*c*) The modulus of rupture for each specimen as calculated in Section 16.

(*d*) The average of the results given in Paragraph (*a*) and the percentage average deviation from the mean.

(*e*) A description of each fracture and the behavior of the material under load.

(*f*) The rate of application of the load.

(*g*) The name and rating of the machine used to make the tests.

(*h*) A curve sheet showing the transverse strength (modulus of rupture) for each specimen, the first value being the lowest and each succeeding one the next higher.

IV. RESISTANCE TO IMPACT.

Apparatus. 18. The test shall be made with an apparatus in which a weight of 1 lb. is raised $\frac{1}{2}$ in. and allowed to fall on the specimen. It is then raised 1 in. and allowed to fall again on the specimen. This is continued, the weight being raised and dropped through a distance increasing by increments of $\frac{1}{2}$ in. until the specimen is broken.

Specimen. 19. The test specimen described in Section 8 shall be used for impact tests.

Procedure. 20. (*a*) The test specimen shall be clamped in the base of the impact tester directly under the hammer. The stops shall be set to give a successively increasing rise of hammer by $\frac{1}{2}$-in. increments, the first height being $\frac{1}{2}$ in.

(*b*) The entire hammer shall weigh 1 lb.

(*c*) The test shall be continued until the specimen cracks.

(*d*) Not less than five specimens shall be tested in the condition in which they are received.

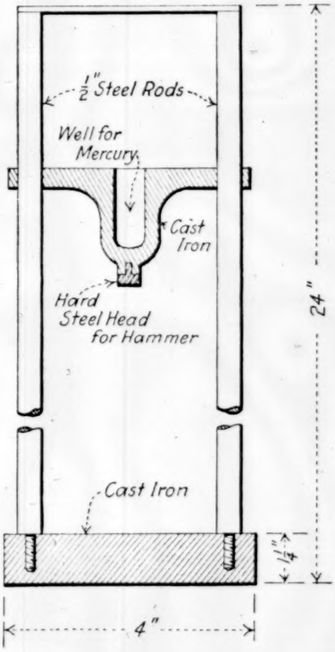


FIG. 5.

Report. 21. The report shall include the number of blows required to break each specimen, the energy of each blow in inch-pounds and the total energy in inch-pounds (that is, the sum of all blows).

NOTE.—The apparatus may be a simple hand-operated one constructed along the line of the one shown in Fig. 5 or a motor-operated machine where the weight is lifted and the distances are increased automatically.

V. DIELECTRIC STRENGTH

Apparatus. 22. The apparatus shall be as described in Section 14 of the Standard Methods of Testing Molded Insulating Materials (Serial Designation: D 48) of the American Society for Testing Materials.[1]

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[1] 1924 Book of A.S.T.M. Standards.

Specimens. 23. The specimens shall be as shown in Fig. 6 except that the threads may be omitted.

Method. 24. (*a*) *Porcelain for all purposes.*—A pad of wet clay about $\frac{1}{4}$ in. thick shall be laid in the groove and a lining of wet clay about $\frac{1}{4}$ in. thick put on the inside of the specimen. The potential shall be applied to these two pads of clay by any suitable means. Mercury may be substituted for the wet clay if desired. The test should preferably be made in air but it may be made in transformer oil if necessary.

Not less than ten specimens shall be punctured in their normal condition at a normal room temperature of about 20° C. (68° F.).

(*b*) *Porcelain for transmission line insulators.*—In addition to the test prescribed in Paragraph (*a*), not less than 10 specimens shall be tested in the same manner at a temperature of 75° C. (167° F.).

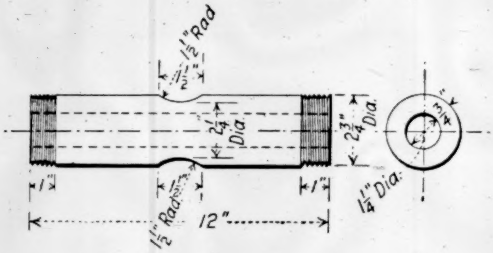

FIG. 6.

(*c*) *Porcelain for spark plugs.*—In addition to the test prescribed in Paragraph (*a*), not less than 10 specimens shall be tested to determine the effect of high temperatures on the dielectric strength. The specimens shall be placed in an electrically heated oven the temperature of which can be raised at a constant rate to 600° C. (1112° F.). A given voltage shall be applied and maintained constant and the temperature raised at any constant rate such that the porcelain is always practically at the temperature of the air. The temperature shall be raised until puncture occurs.

(*d*) Whenever a puncture occurs at a point other than the minimum section of the specimen in any of the tests prescribed above, that result shall be discarded.

Report. 25. The report shall include the following:

(*a*) A statement of the purpose for which the porcelain is intended and the kind of tests which were made.

(*b*) The thickness of the specimen at the bottom of the groove.

(*c*) The voltage at puncture for each of the test specimens together with the average, maximum and mimimum volts per mil or per millimeter of thickness.

VI. RESISTANCE TO THERMAL CHANGE

(*A*) *Porcelain for Transmission Line Insulators.*

Apparatus. 26. The apparatus shall consist of a hot water bath maintained at a temperature of 100° C. (212° F.) and an ice water bath maintained at 0° C. (32° F.).

Specimens. 27. The test specimens shall be as shown in Fig. 6.

Method. 28. (*a*) The test specimen shall be immersed in the ice water bath for ten minutes and then transferred as quickly as possible to the hot water bath, and allowed to remain there for ten minutes. The specimen shall be transferred back to the cold water and the cycles continued until the specimen breaks.

(*b*) Not less than five specimens shall be tested.

Report. 29. Report the number of cycles necessary to cause fracture of each test specimen.

(*B*) *Porcelain for Spark Plugs and Heating Devices.*

Apparatus. 30. A furnace in which a temperature of 900° C. (1652° F.) can be obtained and any suitable testing machine for determining the tarnsverse strength of small beams may be used.

Specimens. 31. The specimens shall be as described in Section 13.

Method. 32. (*a*) One-half of not less than 12 specimens shall be taken and placed in the furnace. The rate of heating shall be so adjusted that the temperature reaches 900° C. (1652° F.) in two hours. The furnace shall then be allowed to cool at such a rate that room temperature is reached in four hours.

(*b*) All specimens for transverse strength shall be tested by placing them on supports 5 in. apart and loading them at the center.

Report. 33. The report shall include the following:

(*a*) The load in pounds or kilograms required to break each specimen not subjected to heat treatment, together with the average.

(*b*) The load required to break each specimen that was subjected to heat treatment, together with the average.

(*c*) The percentage loss of strength due to heat treatment calculated from the two averages.

VII. POROSITY

Water Absorption.[1]

Apparatus. 34. Any good chemical balance, a beaker of distilled water at normal room temperature of about 20° C. (68° F.) and an oven of any standard make capable of maintaining a uniform temperature at the desired point within ±5° C. shall be provided.

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[1] Committee D-9 is studying a method for determining quantitatively the pore volume in porcelain with the hope that it will be practicable to supersede the former dye penetration methods. (See report of Committee D-9 for 1926.)

Specimens. 35. A single piece of porcelain shall be used weighing from 30 to 50 g. and with at least 50 per cent of the surface newly fractured.

Method. 36. The specimen shall be dried for 24 hours at 120° C. (248° F.), cooled in a desiccator and weighed. The specimen shall then be totally submerged in the distilled water at room temperature (about 20° C.) and allowed to remain submerged for 100 hours. The water shall be boiled for approximately one hour during the first, twenty-fifth, forty-ninth and seventy-third hours. The specimen shall be removed at the end of the 100-hour period, the surface moisture carefully dried off with a clean, dry cloth and the specimen weighed.

Report. 37. The report shall include the following:

(*a*) The original weight of the specimen;

(*b*) The dry weight of the specimen;

(*c*) The dry weight of the specimen after immersion for 100 hours;

(*d*) The percentage of moisture content in each specimen as received and the percentage of moisture absorbed during 100 hours, taking the dry weight as 100 per cent, and the average where more than one specimen is tested.

TENTATIVE METHODS OF TESTING ELECTRICAL INSULATING OILS[1]

Serial Designation: D 117 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope.

1. These tests are intended for oil used in transformers, oil circuit breakers and other electrical apparatus as an insulating or cooling medium, or both.

I. SAMPLING

Sampling.

2. Some of the tests, notably dielectric strength and sludge tests,[2] of this class of material are very greatly affected by the most minute traces of certain impurities. Moisture, for example, greatly affects the dielectric test. It is exceedingly important that the samples be handled with the utmost care to avoid contamination. Therefore the following procedure and precautions shall be observed in obtaining and transporting samples of the oil to be tested.

Apparatus for Sampling.

3. (*a*) *Containers for Samples.*—Tin cans, or clear glass cork-stoppered bottles in cartons may be used. Containers shall be chemically clean and dry.

NOTE.—The glass bottle offers the advantage that it may be examined to see that it is clean. It also allows visual inspection of the oil before testing, particularly as regards free water and solid impurities. However, if samples are placed in glass bottles, they shall be kept in the dark until the portions are removed for testing for color and sludge forming characteristics, as light produces changes in these properties. Rubber stoppers should never be used with the glass containers. Only good quality cork should be used with a new cork for each sample. Contact of the oil with the cork may be prevented by means of wrapping around the cork before forcing it into the mouth of the bottle some pure thin tin foil or a similar material not attacked by oil. The tin can fitted with a screw cap protected with a non-absorbent gasket will endure harder usage. Tin cans should be soldered on the exterior surfaces.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

These Tentative Methods, when adopted as standard, will supersede the present Standard Methods of Testing Transformer and Switch Oils (Serial Designation: D 117 – 24), 1924 Book of A.S.T.M. Standards.

[2] The great importance of a sludging test is recognized but none is included in this Standard at this time because none of the methods in general use are considered sufficiently satisfactory by Committee D-9 to warrant consideration for standardization purposes. Certain new methods are being actively investigated. See reports of Committee D-9 for 1922, 1923, 1924 and 1925.

(*b*) *Thiefs.*—When sampling a shipment of oil, enough thiefs should be provided to insure drainage of each before it is used a second time. For obtaining only a few samples, two or three thiefs are enough, but for sampling a car lot of drummed oil, six or more are desirable.

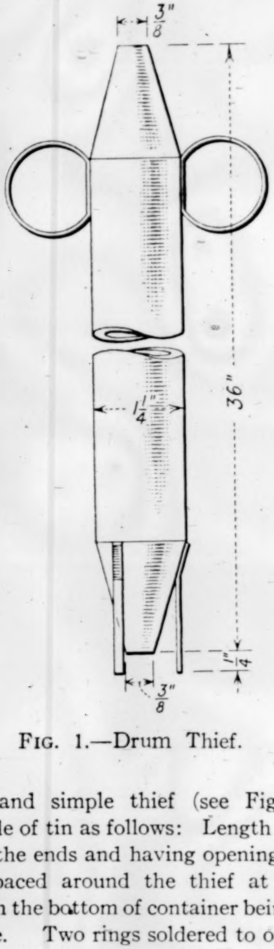

FIG. 1.—Drum Thief.

NOTE.—A convenient and simple thief (see Fig. 1) for use with 50-gal. drum containers may be made of tin as follows: Length 36 in. and diameter $1\frac{1}{4}$ in., with cone-shaped caps over the ends and having openings at the ends $\frac{3}{8}$ in. in diameter. Three legs equally spaced around the thief at the bottom, long enough to hold the opening $\frac{1}{4}$ in. from the bottom of container being sampled, aids in securing a good representative sample. Two rings soldered to opposite sides of the tube at the upper end will be found convenient for holding the thief by slipping two fingers through them, leaving the thumb free to close the opening. For tank cars, a thief employing a trap at the bottom may be used.

Cleaning of Sampling Apparatus. 4. All thiefs and sampling receptacles shall be thoroughly cleaned before using, special care being taken that no lint or other fibrous material remains in or on them.

NOTE.—It is suggested that the thiefs be cleaned by rinsing with oil-free gasoline and dried in the hot cabinet (see Section 5) before using. The best procedure is to rinse them after the sampling has been finished and then place them in the hot cabinet. They will in this way be ready for use without further cleaning when the next shipment is to be sampled.

All sample containers before using should be rinsed with oil-free gasoline and dried. They should then be washed with strong soapsuds, rinsed thoroughly with water and then dried in an oven at 105 to 110° C. A similar washing will be sufficient for re-use of the containers for samples of new oil, but those for used oil should be washed with both gasoline and benzol before using soapsuds. Containers which are not chemically clean and dry are likely to contaminate the sample of oil and cause misleading results in some of the tests.

Storage of Sampling Apparatus.

5. When not in use all sampling apparatus should be kept in a hot, dry, dust-free cabinet or compartment at a temperature not less than 38° C. (100° F). Containers for samples, after washing and drying as indicated in Section 4, shall be kept unstoppered while in the oven or hot cabinet but shall be closed immediately after they are taken out of the hot cabinet. However, it is permissible to prepare containers in advance, leaving them in the 105 to 110° C. oven until dry, then removing, corking or capping and sealing by dipping the neck into melted paraffin wax. Bottles shall, before dipping, have cork and neck wrapped with paper, and securely tied. If this procedure is followed, before removing the cork or cap preparatory to filling the bottle or can with the sample, care must be taken to remove the paraffin so as to prevent its contaminating the sample. Thiefs shall be kept at all times in a vertical position in the hot cabinet in a rack having a suitable drainage receptacle at the base.

Procedure for New Oils.

6. (*a*) It is recommended that one quart of oil be taken as a sample if complete physical and chemical tests are to be made; at least one pint if the dielectric test alone is to be made.

(*b*) Drums or tank cars, etc., of oil shall not be sampled until the oil is at least as warm as the surrounding air. Electrical insulating oil is not hygroscopic but cold oil may condense enough moisture on the surface from a humid atmosphere to seriously affect its insulating properties.

(*c*) Samples of oil shall be taken only after the oil has remained undisturbed and has settled for at least 8 hours. Samples must, of course, never be taken in the rain and precautions must be taken during sampling to prevent contamination by wind-blown dust, etc.

(*d*) Drums and barrels of oil to be sampled should be lined up and numbered, bungs up. The bungs shall be unsealed and removed and laid with the oily side up beside the bung holes. The unstoppered sampling receptacle can be placed on the opposite side of the bung holes. The top hole of the thief-tube shall be closed with the thumb, the tube thrust to the bottom of the container and the thumb removed.

When the thief-tube is filled the thumb shall be replaced, the tube quickly withdrawn and the contents allowed to flow into the sampling receptacle. The lower holes shall not be closed with the fingers of the other hand. The free hand shall be used to guide the stream of oil by touching the thief-tube only as necessary. The oil shall not be allowed to flow over the hand or fingers before it flows into the sample receptacle nor shall any excess be allowed to flow over the drum and back into the drum through the open bung hole. When the sampling receptacle is filled it shall be closed quickly and the bung replaced in the container and tightened. The sampling receptacle shall be taken to the testing laboratory as quickly as feasible.

(*e*) Tank cars of oil shall be sampled with the thief, introducing it through the manhole on top of the car, the cover of which shall be removed carefully so as not to introduce any dirt into the oil. The sample shall be taken as near as possible to the bottom of the tank car.

Procedure for Oil in Service.

7. (*a*) When taking samples of oil from transformers, oil circuit breakers and other apparatus where a thief-tube or cup cannot be used, the cautions outlined in Section 6 shall be observed as far as practicable. In addition, care shall be taken to procure a sample which fairly represents the oil at the bottom of the tank. Transformer and oil circuit-breaker tanks, etc., are usually provided with drain pipes or sampling cocks from which the sample can be allowed to flow into the sample container. Sufficient oil should be allowed to flow to waste before the test sample is taken to insure that the sample will not be that portion which was stored in the drain pipe. For this reason the valve and the drain pipe should be sufficiently small to be emptied with convenience and yet sufficiently large to give an even flow of oil and avoid clogging by sediment. A $\frac{1}{4}$-in. pipe and valve are recommended. This, of course, may be separate from the drainage pipe and valve or may be connected to the drainage valve by means of a suitable reducer.

III. VISCOSITY

Viscosity.

8. The viscosity test shall be made in accordance with the Standard Methods of Test for Viscosity of Petroleum Products and Lubricants (Serial Designation: D 88) of the American Society for Testing Materials[1] and unless otherwise directed shall be taken at a temperature of 37.8° C. (100° F.).

IV. FLASH POINT

Flash Point.

9. The flash point shall be determined in accordance with the Standard Method of Test for Flash and Fire Points by Means of

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[1] A.S.T.M. Standards Adopted in 1926.

Open Cup (Serial Designation: D 92) of the American Society for Testing Materials.[1]

V. POUR POINT

Pour Point. 10. The pour point shall be determined in accordance with the Tentative Method of Test for Cloud and Pour Points of Petroleum Products (Serial Designation: D 97 - 25 T) of the American Society for Testing Materials.[2]

VI. NEUTRALIZATION NUMBER

Neutralization Number. 11. The neutralization number shall be determined in accordance with the Tentative Method of Test for Neutralization Number of Petroleum Products and Lubricants (Serial Designation: D 188 - 26 T) of the American Society for Testing Materials,[3] using method A, Section 4.

VII. MINERAL ACIDS (CHLORIDES AND SULFATES)

Mineral Acids. 12. The presence of mineral acids (Cl or SO_3) shall be determined by thoroughly shaking in a separatory funnel, 100 cc. of the oil with 50 to 100 cc. of hot (90 to 100° C.) distilled water and then separating and drawing off the water layer and testing it qualitatively with the usual procedures for the presence of chlorides or sulfates.

VIII. FREE AND CORROSIVE SULFUR

Apparatus. 14. (*a*) The apparatus for this determination should consist of the following:

(*a*) Electrolytic sheet copper: approximate dimensions:—length, 3 in. (7.62 cm.); width, 0.5 in. (1.27 cm.); thickness, 0.031 in. (0.079 cm.).

(*b*) Glass tube: acid-resistant glass, 125 cc. capacity, fitted with a slotted cork (a test tube of suitable size is satisfactory).

(*c*) Suitable bath in which a temperature of from 95 to 110° C. can be maintained.

Reagents. 15. *Reagents.*—The following reagents will be required:

(*a*) Fuming nitric acid, c. p.;
(*b*) Hydrochloric acid, c. p. concentrated;
(*c*) Barium chloride, 10-per-cent solution.

Procedure. 16. The copper strip shall be mechanically polished. It shall be thoroughly washed with distilled water to remove the polishing compounds and dried between filter paper. The polished copper strip shall be placed in the glass tube and 100 cc. of oil added. The strip shall be completely immersed. The tube shall be closed with a vented cork and the oil heated in the bath for not less than five hours, maintaining on the oil sample a temperature between 95 and 110° C.

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[1] 1924 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 725 (1925); also Book of A.S.T.M. Tentative Standards, p. 474.

[3] See p. 852.

If free sulfur or corrosive sulfur compounds are present, the copper strip will be discolored. This discoloration (a dark characteristic film) is not definite proof of the presence of free sulfur or corrosive-sulfur compounds. It shall be tested as follows:

Remove the oil from the copper strip by rinsing with petroleum ether. After the ether has evaporated, completely dissolve the discoloring film with a few drops of fuming nitric acid, catching the solution in a 50-cc. beaker. In this manner a minimum of copper is removed. Wash the strip with a minimum of distilled water, catching the washings in the beaker. To the combined solution, add about 5 cc. of concentrated hydrochloric acid. Boil the solution to drive off free nitric acid. If necessary, dilute with a small amount of distilled water, and then to the boiling solution add 5 cc. of the 10-per-cent solution of barium chloride. A white precipitate proves the presence of sulfur. Minute traces of sulfur are not precipitated immediately. If no precipitate forms in six hours, the temperature of the solution having been maintained at about 95° C., free sulfur or corrosive-sulfur compounds shall be considered absent.

NOTE.—All reagents shall be sulfur-free. A blank should be run with each batch of determinations, following the above procedure, but using water in equal volume instead of oil. With necessary precautions the volume of solution for proving the presence or absence of sulfur should not exceed 20 to 30 cc. throughout the manipulation.

IX. DIELECTRIC STRENGTH

Apparatus. 17. (*a*) The apparatus shall be as described in Section 14 of the Standard Methods of Testing Molded Insulating Materials (Serial Designation: D 48) of the American Society for Testing Materials.[1] The test cup for holding the sample of oil shall be made of a material having a suitable dielectric strength (at least 50,000 kv). It must be insoluble in and unattacked by mineral oil and gasoline and non-absorbent as far as moisture, mineral oil and gasoline are concerned. The electrodes in the test cup between which the sample is tested shall be circular disks of polished brass or copper, one inch in diameter and having square edges. The electrodes shall be mounted in the test cup having their axes horizontal and coincident, with a gap of 0.1 in. between their adjacent faces, and with top of electrodes about 33 mm. ($1\frac{1}{4}$ in.) below the top of the cup.

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[1] 1924 Book of A.S.T.M. Standards.

Procedure.

18. (*a*) The electrodes and the test cup shall be wiped clean with dry calendered tissue paper or with a clean dry chamois skin and thoroughly rinsed with oil-free dry gasoline until they are entirely free from fibers.

(*b*) The spacing of electrodes shall be checked with a standard round gage having a diameter of 0.100 in. and the electrodes then locked in position. Care shall be taken not to touch the electrodes with the gage or in any other manner after cleaning the electrodes and cup, so as to avoid any possible contamination.

(*c*) The test cup shall be filled with dry gasoline, and voltage applied with uniform increase at the rate of approximately 3000 volts (rms.) per second until breakdown occurs. If the dielectric strength is not less than 25 kv., the cup shall be considered in suitable condition for testing the oil. If a lower test value is obtained the cup shall be cleaned with gasoline and the test repeated.

NOTE.—Evaporation of gasoline from the electrodes may chill them sufficiently to cause moisture to condense on their surface. For this reason, after the final rinsing with gasoline, the test cup should be immediately filled with the oil which is being tested and the test proceeded with at once, or the electrodes should be thoroughly dried.

(*d*) The temperature of the oil when tested shall be the same as that of the room which should be between 20 and 30° C. (68 and 86° F.). Testing at lower temperatures is likely to give variable results which may be misleading.

(*e*) The sample in the container shall be shaken so as to thoroughly mix the oil before filling the test cup. This is even more important with used than with new oil as the impurities may settle to the bottom and the test may be misleading.

(*f*) The cup shall be filled with oil to a height of not less than 20 mm. (0.787 in.) above the top of the electrodes.

(*g*) The oil shall be gently agitated by rocking the cup and then the oil shall be allowed to stand in the cup for three minutes before the first and one minute before each succeeding puncture. This will allow air bubbles to escape.

(*h*) Voltage shall be applied and increased uniformly at a rate of approximately 3000 volts (rms.) per second until breakdown occurs as indicated by a continuous discharge across the gap. (Occasional momentary discharges which do not result in a permanent arc may occur; these should be disregarded.)

(*i*) Provision shall be made for opening the circuit as promptly as possible after breakdown has occurred in order to prevent unnecessary carbonizatio of the oil. After each puncture, the testing vessel shall be jarred to loosen particles of carbon adhering to the electrodes and the oil gently agitated but not with sufficient violence to introduce air bubbles.

(*j*) Five breakdowns shall be made on each filling after which the vessel shall be emptied and refilled with fresh oil from the original sample. The test shall be continued until the averaged values of at least three fillings do not differ from their mean by more than 10 per cent.

(*k*) The last filling of the cup should drain the container. If a quart sample be received, allowance shall be made in withdrawing portions so that just enough be left for a final filling of the cup with the drainings from the container.

Report. 19. The report shall include the following:

(*a*) The volts (rms. value) at each puncture, the average voltage for each of the three or more fillings and the grand average;

(*b*) The report shall be stated as kv., 1.0 in. disk 0.1 in. gap;

(*c*) The approximate temperature of the oil at the time of the test.

NOTE.—A precision of about 3 per cent may reasonably be expected in 15 tests distributed among three consistent fillings taken in succession. But if the length of the gap is readjusted and possibilities of contamination exist, the precision may be only 6 or 7 per cent. Differences as great as 10 or 12 per cent may occur between different laboratories even where the work is carefully done. (See Appendix I to Report of Committee D-9 of the American Society for Testing Materials in 1921.)

TENTATIVE METHODS OF TESTING SHEET AND TAPE INSULATING MATERIALS FOR DIELECTRIC STRENGTH[1]

Serial Designation: D 149 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1922; REVISED, 1923, 1924, 1926.

Scope. 1. These methods are designed to determine the dielectric strength of sheet and tape insulating materials. Since the dielectric strength of such materials is dependent upon the time of application of the electrical tension, two tests differing in time duration are included as *A*, Short-Time Dielectric Strength Test, and *B*, One-Minute Step-by-Step Dielectric Strength Test, respectively.

A third test, designated as an Endurance Dielectric Strength Test, is included under *C*. It shows the relative dielectric strength of different flexible sheet and tape insulating materials at high temperature when subjected to electrical tensions for relatively long periods.

It should be noted that the results obtained with the electrodes specified for sheet material will differ from those specified for tape material (Section 3) and will not be comparable because the apparent dielectric strength of thin materials varies with the area of the electrodes.

A. Short-Time Dielectric Strength Test

I. APPARATUS

High-Voltage Transformer. 2. (*a*) Any well-designed, high-tension transformer connected to an alternating current supply, having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall be not less than 2 kva. for voltages of 50,000 volts or less, and not less than 5 kva. for voltages above 50,000 volts. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high-tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point and in no case more than 500 volts at a step. The control may be made by generator field regulation, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than 10 per cent from a sinusoidal shape.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

(*c*) The voltage may be measured by any approved method which gives root-mean-square values, preferably by means of a voltmeter connected to a special voltmeter coil in the high-tension winding of the testing transformer, or to a separate step-down instrument potential transformer. A voltmeter on the low-tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high-tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

(*d*) Some protection is desirable in the high-tension circuit of testing transformers where the potential is 25,000 volts or over, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils is used in series with the high-tension terminals, it should not be greater than that which will limit the high-tension current to double the normal rated current of the testing transformer.

When a spark gap is used, a non-inductive resistance of about one ohm per volt should be inserted in series with one terminal of the spark gap, to damp high-frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible. If the test is made with one side grounded, this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded, the resistance shall be inserted one-half on each side of the spark gap. Water tube resistors are preferable to carbon for this purpose, as carbon resistance may be materially decreased by the passage of current.

(*e*) The apparatus used and the method of measuring the voltage shall meet the requirements of the Standards of the American Institute of Electrical Engineers.

Electrodes. 3. The electrodes shall be of brass or copper with flat polished contact surfaces. For sheet material they shall be cylinders 2 in. (50.8 mm.) in diameter and 1 in. (25.4 mm.) in length with the edges rounded to a radius of $\frac{1}{4}$ in. (6.35 mm.). For tapes the electrodes shall be cylindrical rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.) and the upper movable one shall weigh 0.1 lb. (45.4 g.) ± 0.005 lb. (2.3 g.).

II. TEST SPECIMENS

Test Specimens. 4. (*a*) The test specimens may be of any convenient size, but the total area of the specimens of one sample of material shall be sufficient to permit making at least ten satisfactory tests.

(*b*) The specimens shall be representative of the material to be tested, care being taken to select material which is free from abnormal defects such as blisters, wrinkles, cracks, etc.

III. PROCEDURE

Surrounding Medium. 5. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes. 6. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen. 7. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

8. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage. 9. Starting at zero, the voltage shall be increased uniformly to breakdown at a rate of 0.5 kilovolt per second, except that if breakdown occurs at this rate in less than 40 seconds, the rate shall be decreased so that breakdown will occur in not less than 40 seconds. If the material fails at less than 5 kilovolts, the minimum time shall be reduced from 40 seconds to 20 seconds.

Number of Tests. 10. Ten tests shall be made and the average of these ten puncturing voltages shall be taken.

Thickness. 11. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 12. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent;

(*f*) The duration of the test.

B. One-Minute Step-by-Step Dielectric Strength Test

IV. APPARATUS

Apparatus. 13. The apparatus shall consist of the high-voltage transformer and the electrodes specified in Sections 2 and 3.

V. TEST SPECIMENS

Test Specimens. 14. The test specimens shall be as specified in Section 4.

VI. PROCEDURE

Surrounding Medium. 15. The tests shall be made in air with the specimen at room temperature.

Condition of Electrodes. 16. The testing electrodes shall be kept clean and polished.

Position of Electrodes and Specimen. 17. The electrodes shall be self-aligning, and shall be placed exactly opposite one another with the specimen in a horizontal plane between them.

18. The edges of tapes shall be clamped between blocks of insulating material under a pressure of approximately 100 lb. per sq. in. to prevent flashover occurring before puncture.

NOTE.—In the Appendix are shown two different devices which have been found satisfactory for these tests.

Application of Voltage. 19. A voltage shall be applied which is equal to 40 per cent of the breakdown voltage obtained in the short-time test to the nearest even 1000 volts (or 500 volts with low voltages). The voltage shall then be increased by 10 per cent of the initial value until failure occurs, the voltage being held at each step for one minute. When changing from one step to a higher step, the voltage shall be increased to the required value within 10 seconds.

Number of Tests. 20. Five tests shall be made and the average of these five puncturing voltages shall be taken.

Thickness. 21. The thickness of the specimen shall be measured at each puncture, using a ratchet micrometer graduated to 0.001 in. and having a circular foot not less than 0.240 in. nor more than 0.260 in. in diameter.

Report. 22. The report shall include the following:

(*a*) The thickness of the specimen at each puncture;

(*b*) Total volts and volts per mil of thickness at each puncture;

(*c*) The average, maximum and minimum volts at puncture per mil of thickness for each sample;

(*d*) The room temperature;

(*e*) The relative humidity, in per cent;

(*f*) The duration of the test;

(*g*) The value of the initially applied voltage and the value of the voltage at each step.

C. Endurance Dielectric Strength Test

VII. APPARATUS

23. The apparatus shall consist of the high-voltage transformer specified in Section 2. **Apparatus.**

24. (*a*) The specimens shall be made by wrapping the material, in tape form with one-quarter lap, one-half lap, butt jointed or as sheets, on brass tubes. The tubes shall be, for sheets and for tape up to $1\frac{1}{2}$ in. in width, about 36 in. in length and 1 in. in outside diameter. For tapes wider than $1\frac{1}{2}$ in., the tubes shall be 2 in. in outside diameter. The sample shall be built up to the desired thickness, simulating practical conditions, winding all layers of tape in the same direction. **Test Specimen.**

(*b*) A smooth layer of metal foil shall then be wrapped over the insulation for a distance of 24 in., leaving 6 in. of insulation uncovered at each end of the tube. The metal foil shall be bound in place with a wrapping of adhesive tape and shall extend the full length of the tube in order to protect the insulation at the end from corona discharge.

(*c*) A thermocouple shall be applied to the metal foil near the center of the tube and held in place by the adhesive tape.

VIII. PROCEDURE

25. The specimen shall be mounted in an oven and a temperature of 100° C. (212° F.) maintained during the test. Provision shall be made for so mounting the specimen that the tube may be connected to the high voltage side of the circuit with the metal foil sheath and thermocouple connected to ground. **Position of Specimen.**

26. A voltage equal to 10 per cent of the breakdown voltage (to the nearest kilovolt) obtained in the short-time test (Test *A*) shall be applied and maintained for 30 minutes. The voltage shall then be increased by steps of 20 per cent of the initial value until puncture occurs, the voltage being held at each step for 30 minutes. **Application of Voltage.**

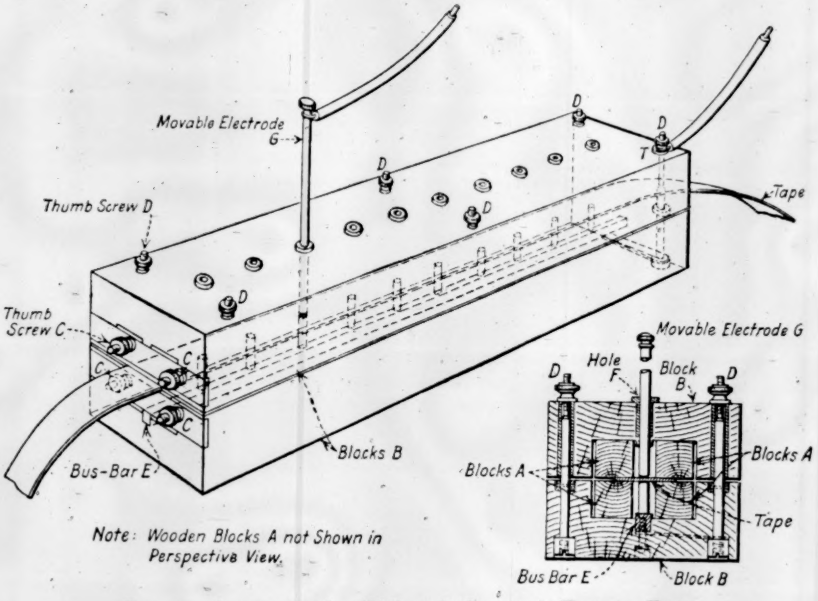
27. The temperature of the sample as indicated by the thermocouple shall be observed at intervals during the test and recorded at the end of each 30-minute period. It will be found that the temperature rises gradually until just before breakdown when the temperature increases rapidly. During this latter period, temperature readings shall be recorded at frequent intervals. **Temperature Readings.**

28. (*a*) The results shall be plotted using time, expressed in hours, as abscissas, and temperature, in degrees Centigrade, as ordinates. In addition to time as abscissas, the values of applied kilovolts shall be indicated since the value of kilovolts increases uniformly with **Report.**

time. The significant values to be taken from the curve and reported are:

(1) Duration of test;
(2) Breakdown voltage;
(3) Temperature of specimen at breakdown;
(4) Rate of temperature rise during test.

(*b*) The report shall also include a description of the specimen and its preparation, the thickness of the insulation and the number of layers of insulation.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Movable Electrode G
Hole F
Block B
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Blocks A
Blocks A
Tape
Bus Bar E
Block B

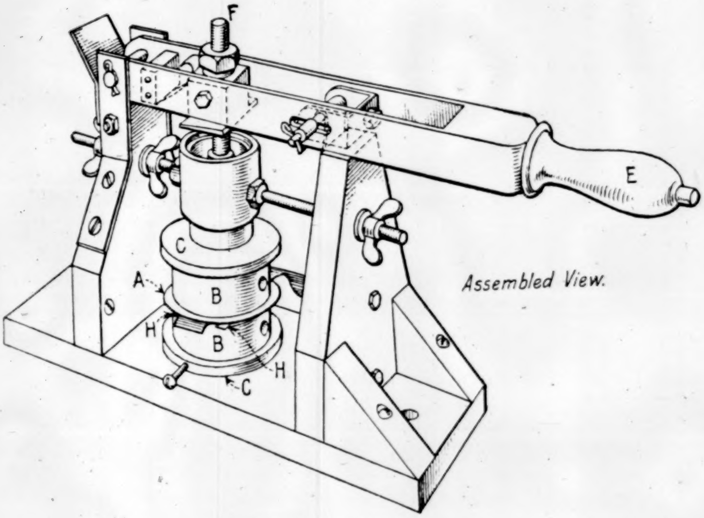
Note: Wooden Blocks A not Shown in Perspective View.

FIG. 1.—Apparatus for Dielectric Strength Test on Tape.

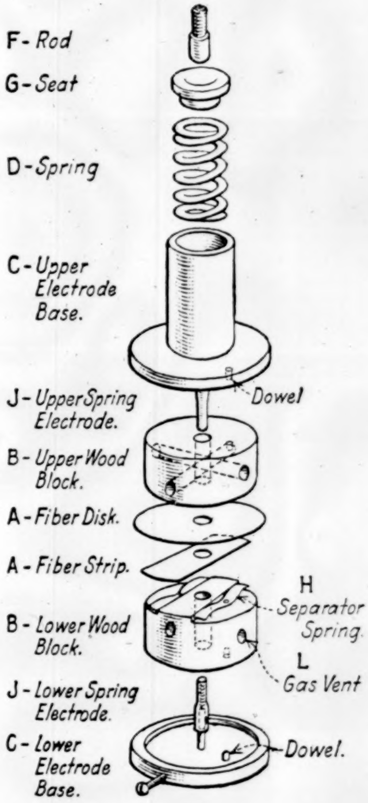
APPENDIX

Figure 1 shows the multiple electrode form of tape tester. In this type, a strip of tape is held between four impregnated wooden blocks, *A*, which are in turn held in place in the two main blocks, *B*, by means of the thumb screws *C* in the ends of the blocks *A*. The blocks *A* are wound butt jointed with 1-in. varnished cloth tape. The whole device is clamped tightly together by the six thumb screws *D*.

There are ten lower electrodes which are fixed to a common bus-bar, *E*. The upper electrode, *G*, is movable and may be inserted into any of the bushed holes *F* which serve to align the upper electrode with the corresponding lower electrode. Voltage is applied between the upper and lower electrodes by direct connection to the upper electrode and by connection to the common bus-bar *E* through the thumb-screw terminal *D* marked *T*. The electrodes are cylin-


F
E
C
A
B
H
B
H
C
Assembled View.

(*a*) Assembled View.


F - Rod
G - Seat
D - Spring
C - Upper Electrode Base.
Dowel
J - Upper Spring Electrode.
B - Upper Wood Block.
A - Fiber Disk.
A - Fiber Strip.
H
Separator Spring.
B - Lower Wood Block.
a
L
Gas Vent
J - Lower Spring Electrode.
C - Lower Electrode Base.
Dowel.

(*b*)

FIG. 2.—**Lever Operated Form of Tape Tester.**

drical brass rods $\frac{1}{4}$ in. (6.35 mm.) in diameter with edges rounded to a radius of $\frac{1}{32}$ in. (0.8 mm.). The weight of the upper electrode is 0.1 lb. (45.4 g.).

After the tape is secured in position, the test is made by moving the upper electrode successively from hole to hole until ten punctures have been obtained.

As more or less carbon is formed during tests, the successful operation of this device depends upon keeping the parts clean. The electrodes should be cleaned with very fine emery paper, being careful not to change their form. The blocks *A* should be rewound from time to time with new varnished cloth tape.

Referring to Fig. 2 (*a*), the tape is held between two pieces of fiber, *A*, which, in turn, are held between two impregnated wood blocks, *B*, held in brass bases, *C*. The blocks are pressed together by a spring, *D*, which is compressed by the latch handle, *E*, through a rounded pin, *F*, fitting into a cup-shaped cap, *G*. When the handle is released, the blocks are spread apart by two light springs, *H*, mounted on the face of the lower block. The electrodes, *J*, consist of hollow rods, fitted with very light internal springs, *K*, which hold the ends against the tape during the test. Vents, *L*, relieve any gas pressure which may develop when puncture occurs.

After considerable use, a leakage path will develop along the surface of one of the blocks and re-surfacing becomes necessary. This condition is avoided by using fiber disks as indicated in Fig. 2 (*b*). These disks are easily removed and replaced as necessary.

TENTATIVE METHODS OF TESTING UNTREATED INSULATING PAPER[1]

Serial Designation: D 202 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1924; REVISED, 1925, 1926.

Material Covered.

1. These methods apply to untreated paper which is to be used as an electrical insulator or as a constituent of a composite material used for electrical insulating purposes.

I. SAMPLING

Sampling.

2. (*a*) From shipments consisting of rolls, a sample of at least 1 sq. yd. in area, cut across the entire width of the roll, shall be taken from every tenth roll in the shipment. From other shipments such as sheets or pads of tape, samples of equivalent area shall be taken in such a manner as to be equally representative of the shipment. In no case shall less than three samples be taken.

NOTE.—It is recommended that several turns of paper from each roll sampled be torn off and discarded before the samples are taken.

(*b*) The tests for physical properties shall be made upon each sample.

(*c*) The tests for acidity,[2] moisture content, size,[2] ash and for identification of fibers[2] shall be made in duplicate upon portions taken from a composite sample. This composite sample shall be made up of a sufficient number of small pieces, each of approximately 6.5 sq.cm. (1 sq. in.) in area taken in nearly equal amounts from each of the samples taken in accordance with Paragraph (*a*).

(*d*) The required number of samples shall be taken at equal intervals across the sheet, the two end samples being taken at the edges of the sheet after removing any damaged paper. When it is not possible to secure the required number of specimens in this manner in going once across the sheet, the selection across the sheet shall be repeated as many times as necessary until the required number of specimens is secured.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

[2] The tests for acidity, size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

II. CONDITIONING SAMPLES

Conditioning. 3. Samples shall be conditioned in air maintained at a relative humidity between 60 and 65 per cent as measured with a sling psychrometer or its equivalent. The temperature of the air shall be maintained as constant as possible at some temperature between the limits of 20 and 30° C. (68 and 86° F.). The samples should remain in the conditioned air for not less than 4 hours prior to the tests and should be supported so as to allow a free circulation around each sample. The following physical tests shall be made in the conditioned air: tensile breaking strength, tearing strength, bursting strength, folding endurance,[1] air resistance, and thickness.

III. MOISTURE CONTENT

Apparatus. 4. A weighing bottle, evaporating dish, thermometer, constant-temperature oven, chemical balance and desiccator are necessary for the test. The weighing bottle should be of convenient size, about 65 mm. (2.56 in.) in height and 45 mm. (1.77 in.) in diameter with a wide mouth provided with a ground-glass stopper. The chemical balance should be sensitive to 0.1 mg.

Specimen. 5. The moisture content figure is used to calculate the percentage of acidity, size, and ash of the paper to the bone-dry basis. It shall be determined on 2 to 5-g. samples selected in accordance with Section 2 (*c*).

If the moisture content of the paper as received at the purchaser's works is desired or at any other stated time, it shall be made on the sample taken at the definitely stated time by cutting small pieces of approximately 6.5 sq. cm. (1 sq. in.) in area from the required number of rolls or pads of tape in accordance with Section 2 (*a*) and immediately placed into an air-tight container.

NOTE.—Since paper adjusts itself, as regards moisture content, to the humidity of the surrounding atmosphere in a very short time (2 or 3 minutes), special care must be exercised to transfer rapidly the sample from the roll or bundle to the container and from the container to the weighing bottle.

Procedure. 6. The sample before drying shall be weighed in the tared bottle with the stopper in place. The bottle shall then be placed in the oven at 100 to 105° C. (212 to 221° F.), the stopper removed and laid alongside of the bottle and the contents transferred to the drying dish. After one hour, while still in the oven, the sample shall be replaced in the weighing bottle, and the bottle stoppered and transferred to the desiccator. The stopper should be removed while the bottle cools. When the specimen and the bottle have cooled to room temperature, the stopper shall be replaced and the bottle with its contents weighed. This process shall be repeated at intervals of one hour until the difference in weight between two successive weighings is not more than 0.2 per cent of the weight of the specimen.

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[1] The tests for size, identification of fibers, and folding endurance do not appear in these methods but will be included as soon as the tests are developed by the committee.

NOTE.—The weighing bottle or sample should not be touched with the fingers during this test.

Report.

7. The moisture content shall be expressed:

(*a*) as a percentage of the weight of the dry sample, and

(*b*) as a percentage of the weight of the undried sample.

IV. THICKNESS

Apparatus.

8. A micrometer of the spring actuated, dial type shall be used. The plunger shall be capable of being raised by the application of an upward pressure to it. The plunger surface shall be circular in shape and 12.7 mm. (0.50 in.) in diameter. The anvil surface shall be plane and circular in shape, the diameter of which shall be not less than 12.7 mm. (0.50 in.). It shall be centered with respect to the plunger surface.

In addition to these requirements, the instrument shall conform to the following:

(*a*) The pressure applied to the plunger necessary to move the pointer from zero toward a positive reading shall be not greater than 1135 g. (40 oz.).

(*b*) The pressure applied to the plunger necessary to just prevent movement of the pointer from zero toward a lower reading shall be not less than 455 g. (16 oz.).

(*c*) The diameter of the dial shall be approximately 15 cm. (6 in.) and shall be graduated preferably in divisions indicating a thickness of 0.0127 mm. (0.0005 in.) and in no case greater than 0.0254 mm. (0.001 in.). Graduations indicating a thickness of 0.0254 mm. (0.001 in.) shall be at least 3 mm. (0.12 in.) apart.

(*d*) Measurements made on standard steel thickness gages shall be within the following tolerances:

INTERVALS	PERMISSIBLE DEVIATION OF READING FROM ACTUAL THICKNESS OF STANDARD STEEL GAGE
0 to 0.25 mm. (0 to 0.01 in.) incl.	±0.0025 mm. (0.0001 in.)
Over 0.25 mm. to 1.02 mm. (0.01 in. to 0.04 in.) incl.	±0.0051 mm. (0.0002 in.)
Over 1.02 mm. to 3.05 mm. (0.04 in. to 0.12 in.) incl.	±0.0102 mm. (0.0004 in.)

(*e*) Convenient means shall be provided for setting the pointer to the zero position.

(*f*) The micrometer shall be tested periodically as outlined above and if it does not conform to these requirements its mechanism should be readjusted.

Specimens. 9. Specimens shall consist of the original samples obtained in accordance with Section 2 (*a*).

Methods. 10. At least five readings shall be taken at regular intervals across the entire width of each specimen. When measuring paper less than 0.05 mm. (0.002 in.) in thickness, a sufficient number of layers to give a reading on the scale of not less than 0.13 mm. (0.005 in.) shall be used.

In making measurements the plunger shall be raised to a point where its lower surface is from 0.45 to 0.55 mm. above the surface of the paper specimen lying in contact with the surface of the fixed anvil. The plunger shall be dropped from this height on the paper without retarding its speed of descent. When the thickness is read, care shall be taken not to touch the instrument.

Report. 11. The average, maximum and minimum thicknesses obtained on each specimen shall be reported.

V. TENSILE BREAKING STRENGTH

Apparatus. 12. (*a*) A testing machine suitably designed for testing paper shall be used. The machine shall preferably be power driven.

(*b*) The capacity of the machine shall not exceed 113 kg. (250 lb.).

(*c*) The machine shall be graduated to read 1 lb. or 1 kg. or less per scale division for testing paper breaking at 22.7 kg. (50 lb.) or over, and to 0.5 lb. or 0.5 kg. or less for testing paper breaking under 22.7 kg. (50 lb.).

Specimens. 13. From each of the samples selected in accordance with Section 2 (*a*), specimens shall be cut at least ten in the machine direction and if practicable, ten in the cross-machine direction. The specimens shall not exceed 2.54 cm. (1 in.) in width and shall be 25.4 cm. (10 in.) in length with clean-cut edges.

Procedure. 14. (*a*) The ratio of the clearance distance between jaws to the width of the specimen shall be not less than 5:1 nor more than 10:1.

(*b*) The rate of travel of the movable jaw shall be constant. It shall preferably be 30.5 cm. (12 in.) per minute, but it may be within the limits of 28 cm. (11 in.) and 33 cm. (13 in.) per minute provided it is constant.

(*c*) All readings obtained when the paper breaks at or in the jaws shall be rejected.

Report. 15. (*a*) The results of the machine-direction specimens and the cross-machine-direction specimens shall be reported separately.

(*b*) The results shall be reported in kilograms or pounds together with the width of the specimen in centimeters or inches and also the average thickness.

(*c*) The maximum, minimum, and average breaking load shall be reported for the machine-direction and the cross-machine direction.

VI. TEARING STRENGTH

Apparatus. 16. The testing machine shall be of the pendulum impulse type so designed as to produce a tear approximately 4.2 cm. (1.66 in.) long. The knife mounted on the machine to cut the slit for the tear shall be maintained sharp.

Specimen. 17. The specimens shall be taken from the original samples obtained in accordance with Section 2 (*b*) and shall be cut 6.3 cm. (2.5 in.) in width and at least 6.3 cm. (2.5 in.) in length. Enough specimens shall be cut so that at least five readings in the machine direction and five readings in the cross-direction, if possible, can be obtained for each original sample.

Method. 18. Enough paper shall be torn so that the readings on the machine shall be not less than 10 nor more than 20 g., unless one paper alone yields a reading greater than 20 g., in which case only one paper shall be torn at one time. Readings obtained when a tear deviates more than 6.3 mm. (0.25 in.) from a straight line, shall be rejected. The readings obtained shall be multiplied by the instrument constant corresponding to the number of sheets torn.

Report. 19. (*a*) The tearing strengths obtained on the machine-direction specimens and on the cross-direction specimens shall be reported separately in grams.

(*b*) The average, the maximum, and the minimum tearing strengths shall be reported for the machine-direction specimens. If possible, similar results shall be reported for the cross-direction specimens.

VII. BURSTING STRENGTH

Apparatus. 20. The testing machine shall have a circular flexible diaphragm 6.44 sq. cm. (1 sq. in.) in area. The pressure chamber shall be filled with glycerin or other suitable pressure medium and shall contain no air spaces. The test specimen shall be held in position over the diaphragm in a clamp having a circular hole approximately 6.44 sq. cm. (1 sq. in.) in area so that the diaphragm will force the paper into the hole when pressure is applied under the diaphragm. The pressure exerted on the diaphragm shall be indicated on a dial, graduated to at least 0.23 kg. (0.5 lb.) for papers giving bursting strengths 18 kg. (40 lb.) or under. A dial graduated 0.45 kg. (1 lb.) may be used in testing papers which give higher bursting strengths. The machine may be either hand-operated or power-driven, the latter being preferable.

Specimen. 21. If practicable, the specimen shall be so cut from the stock as to permit ten bursting tests on a line across the sheet or roll.

Procedure. 22. Ten bursts shall be made. The testing machine shall be driven at a uniform speed of 120 r.p.m. until the specimen bursts.

Report. 23. The report shall include the average, the maximum, and the minimum results obtained.

VIII. ABSORPTION

(RISE OF WATER)

Apparatus. 24. A suitable container and support for specimens and scale is shown in Fig. 1.

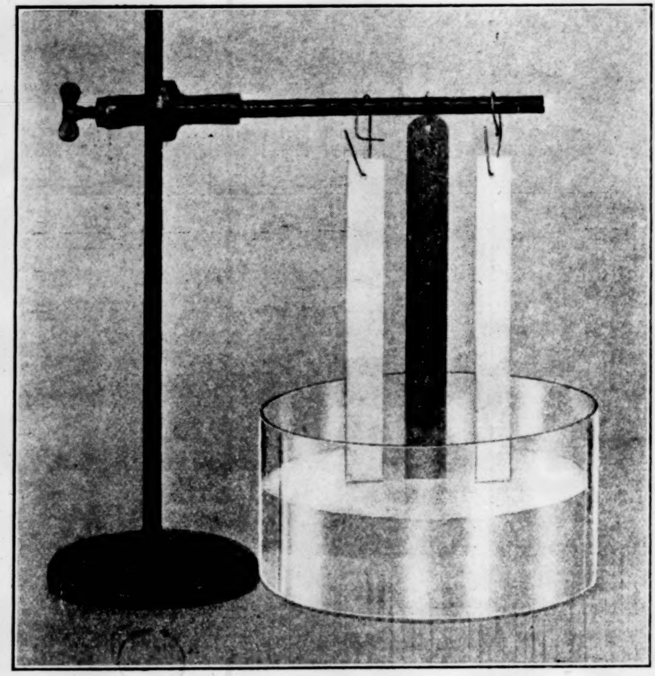

FIG. 1.—Apparatus for Absorption Test.

Specimens. 25. Ten strips 2.5 cm. (1 in.) in width and at least 12.5 cm. (5 in.) in length shall be cut from the samples obtained in accordance with Section 2 (*a*), five being cut parallel with the machine direction of the paper and five being cut parallel with the cross-direction of the paper.

Procedure. 26. The specimens shall be suspended vertically with one end dipping 3.2 mm. (0.125 in.) in distilled water at room temperature.

After five minutes of suspension, the rise of the water in the paper above the water level shall be noted. The rise may be measured by reading directly from the scale the height of absorption.

Report. 27. The rise of water shall be reported in millimeters, to the nearest 3 mm. or in inches to the nearest $\frac{1}{8}$ in.

IX. MIL WEIGHT PER REAM

(APPARENT DENSITY)

Apparatus. 28. A scale, sharp knife, chemical balance and weighing bottle are necessary for the test.

Specimens. 29. Duplicate specimens shall be taken from as widely separated portions as possible from each of the samples obtained in accordance with Section 2 (*a*) and conditioned in accordance with Section 3.

Procedure. 30. (*a*) Each specimen while in the conditioned atmosphere (see Section 3) shall be cut accurately to any convenient size, for example, 232.3 sq. cm. (36 sq. in.) in area, and accurately weighed. Specimens of sufficient size to weigh at least from 3 to 5 g. (0.11 to 0.18 oz.) should be taken. If it is not possible to do the weighing in the conditioned atmosphere, the specimen shall be placed in a weighing bottle and tightly stoppered with a ground glass stopper before being removed from the conditioned atmosphere. The thickness of each specimen shall be determined in accordance with Section 10.

(*b*) *Mil Weight per Ream of Any Size.*—The mil (or point) weight in pounds per ream of any size may be calculated from the following formula:

$$W = 0.002205 \frac{mSN}{ta}$$

where m = the weight of the specimen expressed in grams;
t = the average thickness of the specimen expressed in mils (thousandths of an inch);
a = the area of the specimen expressed in square inches;
S = the area of one sheet in the basic ream expressed in square inches;
N = the number of sheets in the ream.

NOTE.—0.002205 is contracted from 0.00220462.

NOTE.—The following formulas may be used to calculate the mil weight in pounds per ream for reams of particular sizes, provided a specimen of exactly 232.3 sq. cm. (36 sq. in.) is used:

Ream of 24 by 36 in., 480 sheets.

$$W = 25.40 \frac{m}{t}$$

where m = the weight of specimen expressed in grams;
t = the average thickness of the specimen in mils (thousandths of an inch).

25.40 is contracted from 25.3972224.

Ream of 24 by 36 in., 500 sheets.

$$W = 26.45 \frac{m}{t}$$

where m and t are the same as above and 26.45 is contracted from 26.45544.

Note.—The ream weight may be obtained from the above formulas by omitting the thickness "t".

(*c*) *Weight per Unit Volume.*—The weight in pounds per cubic foot (density) may be calculated from the following formula:

$$D = 3810 \frac{m}{ta}$$

Where m = the weight of the specimen expressed in grams.
t = the average thickness of the specimen expressed in mils (thousandths of an inch).
a = the area of the specimen expressed in square inches.

Note.—3810 is contracted from 3809.58336.

Note.—To convert weight in pounds per cubic foot to mil weight in pounds per ream of 24 by 36 in., 480 sheets, multiply by 0.24; to convert to mil weight in pounds per ream of 24 by 36 in., 500 sheets, multiply by 0.25.

Report. 31. The weight in pounds per cubic foot or the mil weight per ream shall be reported. The size of the ream must be given when the mil weight per ream is reported.

X. AIR RESISTANCE

Apparatus. 32. (*a*) The instrument shall consist of two aluminum open-top cylinders, one of which is inverted and slides into the other which is fixed. The movable cylinder shall be provided with a circular aperture in the closed end and a flat ring clamp for holding the paper specimen across this aperture.

(*b*) The fixed cylinder shall be 25.4 cm. (10 in.) in height and shall have an external diameter of 8.60 cm. (3.38 in.) and an internal diameter of 8.25 cm. (3.25 in.). Four slender bars, each 18.5 cm. (7.3 in.) long, 3 mm. (0.12 in.) wide and approximately 1.5 mm. (0.06 in.) thick shall be mounted vertically and equi-distantly on the inner surface of the fixed cylinder to act as guide tracks for the movable cylinder. The movable cylinder shall be graduated in units of 50 cc. and shall have a total range of 350 cc. It shall be 25.4 cm. (10 in.) high and shall have an external diameter of 7.62 cm. (3.00 in.) and an internal diameter of 7.35 cm. (2.90 in.). It shall weigh, including the flat ring clamp and the two knurled nuts, 567 g. (20 oz.) ±5 g. (0.18 oz.). The movable cylinder and the flat ring clamp shall have a concentric circular aperture of 6.44 sq. cm. (1.00 sq. in.) in area.

When this aperture is too large for the specimen a similar movable cylinder and flat ring clamp having a concentric circular aperture of 1.61 sq. cm. (0.25 sq. in.) in area shall be used.

NOTE.—Results obtained with apertures of different areas are not directly proportional to the areas of the apertures. The proportionality factor must be determined by experiment.

Specimen. 33. The specimens shall be not less than 3.5 cm. (1.36 in.) nor more than 5.1 cm. (2.0 in.) in width cut from the original samples, taken according to Section 2 (*a*) and shall be as long as the width of the original roll of paper. If the specimens are selected from pads of tape they shall be not less than 2.1 cm. (0.81 in.) nor more than 5.1 cm. (2.0 in.) wide and at least 30 cm. (12 in.) long. There shall be as many specimens as there are original samples.

Procedure. 34. The fixed cylinder shall be placed on a rigid support so that its sides are vertical. Ethylene glycol shall be placed in it to a depth of 12.7 cm. (5 in.). The specimen (one thickness only) shall be secured tightly under the clamp on the movable cylinder completely covering the aperture. The movable cylinder is then floated on the ethylene glycol. The time required for the displacement of a certain amount of air is noted with a stop-watch. If possible, the amount of air displaced should be such that the time of displacement is not less than 20 seconds. The apparatus with its content of ethylene glycol shall be at the temperature of the conditioning room when the readings are taken. The time in seconds required for the displacement of 100 cc. (6.1 cu. in.) through a circular area (one side only) of 6.44 sq. cm. (1 sq. in.) of the paper is known as the air resistance of the paper.

NOTE.—The clamp shall be tested for leakage by substituting a piece of tin foil 0.05 mm. (0.002 in.) in thickness for the paper and testing in the manner described above. When so tested, the leakage shall not exceed the rate of 50 cc. in five hours

The proper procedure for clamping the specimen or tinfoil is to turn both knurled nuts down onto the clamp simultaneously. If only one nut at a time is turned down, the clamp will not fit flat on the specimen and will consequently have an avoidable leak.

Ethylene glycol is used in preference to distilled water because it does not corrode aluminum whereas distilled water does.

Report. 35. The report shall include (1) the number of seconds required for the displacement of 100 cc. (6.1 cu. in.) of air; (2) the area of paper through which the air was displaced; (3) the thickness of the paper as obtained under Section 11 and (4) the room temperature.

XI. ASH

Apparatus. 36. A suitable crucible such as platinum, nickel or porcelain, a balance sensitive to 0.1 mg., and a desiccator are necessary for the test.

Specimen. 37. Not less than 2 g. of dry, finely-divided paper from the "moisture determination" sample as obtained in accordance with Section 6 shall be used.

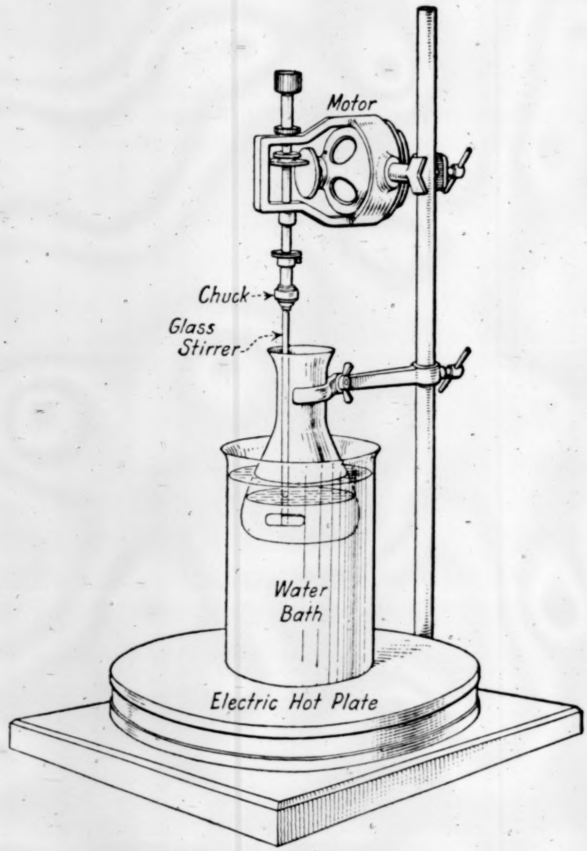

FIG. 2.—Extraction Apparatus.

Procedure. 38. The sample shall be transferred rapidly from the weighing bottle containing the dried sample into the crucible. The weighing bottle shall immediately be re-stoppered and re-weighed, and the exact weight of the sample obtained by taking the difference in weights of the weighing bottle and the sample. The sample shall be completely ignited in the crucible, preferably in a muffle furnace, all precautions being taken to prevent loss of ash or sample. The residue of incombustible mineral matter (ash) shall be desiccated, cooled and weighed, and the amount computed as a percentage of the weight of the dried sample.

Report. 39. The amount of ash shall be reported as a percentage of the weight of the dry sample (see Section 7 (*a*)) and also as a percentage of the weight of the undried sample (see Section 7 (*b*)).

XII. ACIDITY OR ALKALINITY

Apparatus. 40. (*a*) A hot water bath, electric hot plate, motor with stirrer, 50-cc. glass burette graduated to 0.1 cc., 250-cc. wide-mouth Erlenmeyer flasks, thermometer graduated to 1° C., covering the range from 50 to 100° C., and a filtering apparatus, are required for the test.

(*b*) The Erlenmeyer flasks and the stirrer shall be of acid- and alkali-resistant glass. The stirrer shall consist of a glass shaft, one end of which shall be fitted to a chuck attached to the motor shaft (see Fig. 2). The other end of the stirrer shall be fashioned into a two-bladed propeller, each blade to be approximately 15 mm. (0.59 in.) long and 6 mm. (0.24 in.) wide. The pitch of the blades and the direction of rotation shall be such as to produce a downward current along the glass shaft when the stirrer is rotated in the liquid, thus preventing spattering.

(*c*) The following reagents shall be required: Solutions of sodium hydroxide (NaOH) and sulfuric acid (H_2SO_4) in water, each being 0.01 *N* in strength; solution of 0.5 g. of phenolphthalein dissolved in 100 cc. of c. p. ethyl alcohol.

Sample. 41. (*a*) From the original samples obtained according to Section 2 (*a*), a composite sample of at least 5 g. (0.175 oz.) shall be cut into small pieces, approximately 1 cm. (0.4 in.) square. The sample shall be thoroughly mixed, and during preparation contamination by handling shall be avoided.

Procedure. 42. (*a*) *Extraction.*—One gram of the composite sample shall be placed in a 250-cc. Erlenmeyer flask and 100 cc. of boiling, distilled water added. The flask shall then be clamped in position in a water bath[1] heated to 100° C. on a hot plate. The level of the water in the bath shall be slightly above the level of that in the flask, and the temperature of the contents of the flask shall remain at least as high as 95° C. during the stirring operation. The stirrer shall be mounted so that the blades are within 3 mm. (0.12 in.) of the bottom of the flask and offset from the center in order to obtain best beating action. The stirrer shall be driven at a speed of 4000 to 5000 r.p.m. for 5 minutes. At the end of this period the sample should have been thoroughly pulped. For papers unusually difficult to pulp, the period of stirring shall be increased to 10 minutes.[1]

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[1] At high altitudes a salt bath will be necessary to obtain the temperature required.

NOTE.—It has been definitely determined that 3000 r.p.m. is too low to pulp the sample effectively within 5 minutes.

(*b*) *Titration.*—Immediately after the sample has been pulped, the contents of the flask shall be filtered rapidly into another 250-cc. Erlenmeyer flask without washing.

NOTE.—It is important that the filtration of the extract be accomplished as promptly as possible after disintegration to prevent re-absorption of acidic or alkaline material from the extract by the pulp as the temperature falls. A convenient method consists of a 25-cc. porcelain Gooch crucible and holder assembly, like that shown in Fig. 3. The pulp forms a filter mat of itself over the perforations in the bottom of the crucible and the first portion of the filtrate is re-filtered to catch the fibers which go through during the formation of the mat.

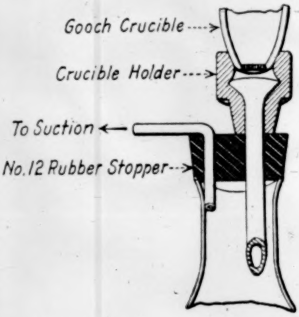

FIG. 3.—Filtration Apparatus.

The filtered extract shall be boiled for 3 minutes and immediately titrated before the temperature falls below 80° C., thus eliminating the error due to dissolved carbon dioxide.

If the extract is acidic, it is titrated with $0.01N$ NaOH, using 5 drops of the specified phenolphthalein solution as indicator. The end-point is determined by the appearance of a definite pink color. If the extract is alkaline, a small excess of $0.01N$ H_2SO_4 is added and the titration then completed with $0.01N$ NaOH as described above.

NOTE.—To find the proper color transformation at the end-point, a blank titration should be made on boiling distilled water under the above specified conditions. The result should check with the curve shown in Fig. 4. This curve will be found valuable as a check on the purity of the distilled water used, although its chief purpose is to indicate the proper blank correction to be applied to the titration.

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[1] Any other method of pulping the sample as rapidly and thoroughly, while maintaining a temperature of 95° C., within the flask during extraction should prove satisfactory.

The number of cubic centimeters of titer solution shall be recorded, together with the temperature and volume of the solution taken immediately upon the completion of the titration, as these figures enter into the blank correction for the volume error (E_v).

43. (*a*) *Blank Correction.*—The correction for the blank error in the titration shall be made in either of two ways: **Report.**

(1) By running a blank in parallel with the actual determination using a volume of pure distilled water equal to that of the extract at the end-point;

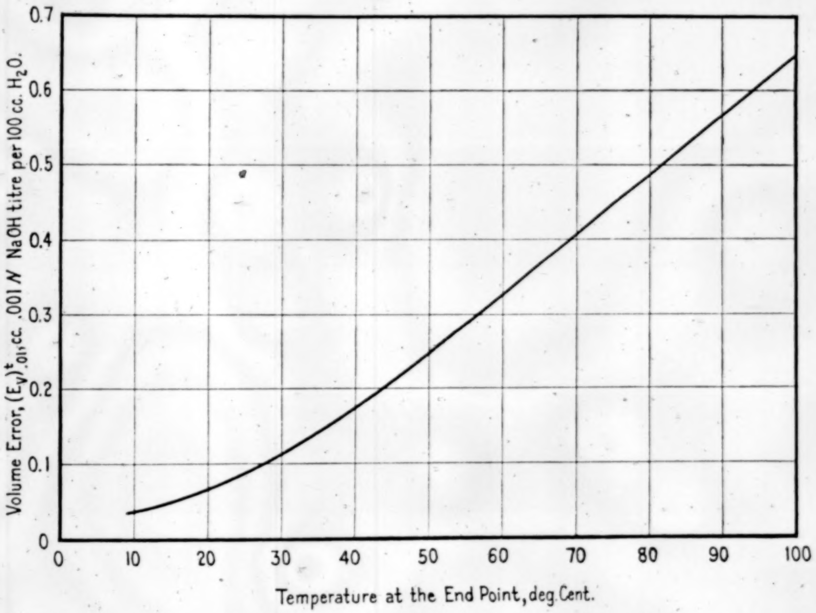

FIG. 4.—Showing Titration Error Due to Volume and Temperature of Water in a Solution at its End-Point.

If $(E_v)\frac{t}{N}$ represents the volume error of a solution where *t* and *V* are the temperature and volume at the end-point of a titration, and $N =$ the normality of the titer, then it is calculated as follows:

$$(E_v)\frac{t}{N} = (E_v)^t{.01} \times \frac{.01}{N} \times \frac{V}{100}$$

(2) By calculating the blank error with the aid of the curve shown in Fig. 4.

NOTE.—The second method is the more convenient and probably more reliable. This curve shows the number of cubic centimeters of 0.01*N* NaOH solution required to produce an end-point at various temperatures in 100 cc. of distilled water, using 5 drops of the specified indicator. Correction by the use of this curve is valid only if the solution has been boiled and titrated at elevated temperatures to insure absence of dissolved CO_2.

This correction is the number of cubic centimeters of titer solution (volume error) corresponding to the point on the curve determined by the temperature and volume of the solution at the end-point. If the solution is acidic, this blank correction shall be subtracted from the volume of titer used; if alkaline the correction shall be added.

(*b*) *Calculation.*—The acidity or alkalinity shall be calculated from the following equation:

$$\text{Per cent acidity (or alkalinity)} = \left\{ \begin{matrix} \text{cubic centimeter} \\ \text{titer solution (corrected)} \end{matrix} \right\} \times \frac{\text{normality}}{1000} \times 40 \times 100$$

A simpler form is:

$$\text{Per cent acidity (or alkalinity)} = \left\{ \begin{matrix} \text{cubic centimeter} \\ \text{titer (corrected)} \end{matrix} \right\} \times \text{normality} \times 4.$$

(*c*) *Expression of Results.*—The results shall be expressed as the equivalent weight per cent of NaOH if the extract is acidic, or as equivalent weight per cent of SO_3 if the extract is alkaline; this percentage being based on the weight of the air-dry sample in grams.

NOTE.—SO_3 is used rather than H_2SO_4 in this calculation as the equivalent weight of SO_3 is identical with that of NaOH, and this makes it possible to express acidity or alkalinity in directly comparable terms.

(*d*) *Number of Tests.*—At least two samples shall be carried through the foregoing procedure. If in duplicate samples the values of percentage acidity or alkalinity do not agree within 0.005, the determinations shall be repeated.

NOTE.—There is given in an appendix to the report of Committee D-9 for 1926, information regarding the details of the foregoing method, and reasons are presented for the selection of the conditions specified.

XIII. SURVEY FOR CONDUCTING PATHS

Scope. 44. The survey for conducting paths in untreated insulating paper is a test to determine the number of conducting paths in the paper as indicated by the number of electrical breakdowns (or points of excessive current flow in thin papers (see Section 45 (*b*)) when relatively large areas of the paper are subjected to a voltage somewhat lower in value than the dielectric strength of the paper when tested in accordance with Sections 2 to 12 of the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (Serial Designation: D 149 - 26 T) of the American Society for Testing Materials.[1]

Apparatus. 45. (*a*) The survey shall be made by passing a specimen of the paper between metallic electrodes across which a voltage is impressed. The arrangement of the apparatus may be of any convenient form which will allow the application of the required voltage to a specimen of relatively large area, and will allow the electrical breakdowns to be indicated so that the number of these may be counted.

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[1] See p. 1029.

(*b*) For papers having a thickness of 0.038 mm. (0.0015 in.) or less it has been found preferable to use a detecting device such as a telephone receiver to detect the excessive current through the conducting paths rather than to allow complete electrical breakdown of the specimen. Also, it is preferable to pass one electrode over the paper rather than to draw the paper through between the electrodes.

Specimens.

46. The specimen shall be of relatively large area, such as a pad of tape, or a sheet from each sample of paper (see Section 2 (*a*)). For sheet material such as pressboard either the entire sheet or a relatively large portion of a sheet shall be used. The specimen shall be representative of the shipment. (Section 2 (*a*)).

Procedure.

47. The survey shall be made by passing the specimen between the metallic electrodes at a speed of 30 to 60 ft. per minute. The voltage impressed across the electrodes shall be 100 volts per mil thickness of the specimen if alternating voltage is used, or 141 volts per mil thickness of the specimen if direct voltage is used.

NOTE 1.—If the voltage values specified above prove inconvenient of application, a lower voltage may be used, in which case it is necessary to establish a relationship between the conducting paths at this voltage and at the specified voltage. A lower value of conducting paths will be obtained at the lower voltage.

NOTE 2.—A description of equipment and a procedure which have been found suitable for making this survey of conducting paths in different thicknesses of paper may be had upon application to the secretary of Committee D-9.

Report.

48. The report shall include the following:

(*a*) The total number of conducting paths and the conducting paths per unit area.
(*b*) The length, width, area, and thickness of the specimen.
(*c*) The voltage applied expressed in volts, and volts per mil thickness of specimen.
(*d*) The speed of the paper.

TENTATIVE METHODS OF TESTING LAMINATED SHEET INSULATING MATERIALS[1]

Serial Designation: D 229 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Scope. 1. These tests apply to laminated flat sheet materials intended for use as electrical insulation.[2]

Definition of Terms. 2. In referring to the cutting of the specimens and the application of the load, the following definitions apply:

Flatwise.—Load applied to the face of the laminations.

Edgewise.—Load applied to the edge of the laminations.

Lengthwise.—In the direction of the length of the sheet.

Crosswise.—In the direction at right angles to the length of the sheet.

NOTE.—When the sheet has the same length and width, one dimension shall arbitrarily be designated as the length, and the other as the width.

I. TENSILE STRENGTH

Apparatus. 3. Any standard type of testing machine may be used. The machine shall be accurate to within 1 per cent on the lowest load for which it is used. Jaws which tighten under load, such as wedge grip jaws, shall be used with the specimen properly aligned.

Specimens. 4. Tension test specimens shall conform to the dimensions shown in Fig. 1. The surfaces of the specimen shall be smooth and free from scratches.

Procedure. 5. Five specimens cut lengthwise and five specimens cut crosswise of the sheet shall be tested.

Temperature. 6. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 7. The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but shall not exceed 0.05 in. per minute when the machine is running idle.

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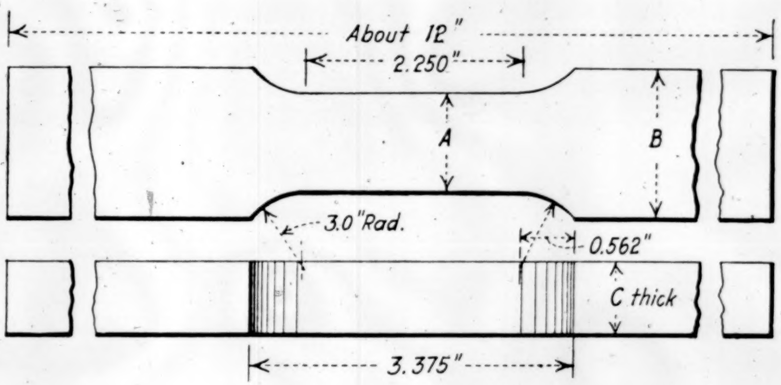
[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

[2] Tests for shearing strength, compressive strength, moisture absorption, oil absorption and degree of curing are being studied by the committee. Various mechanical tests, particularly applicable to thin laminated sheet materials, are being developed.

8. When it is desired to obtain the modulus of elasticity, a suitable extensometer measuring the elongation on a 2-in. gage length shall be used. The cross-head speed of the testing machine shall not exceed 0.03 in. per minute when the machine is running idle.

9. Strain readings shall be taken by increments of load not exceeding about 1000 lb. per sq. in. The modulus shall be calculated from the total change of length between zero load and stress of 5000 lb. per sq. in.

NOTE.—For some materials the stress strain curve will not form a straight line, but will be a continuous curve from the origin to the breaking load.



When C is less than $\frac{1}{8}$ in., A is $\frac{1}{2}$ in., B is $\frac{3}{4}$ in.
When C is over $\frac{1}{8}$ in., or over, A is 1 in., B is $1\frac{1}{2}$ in.

FIG. 1.—Tension Test Specimen for Laminated Sheet Insulating Materials.

10. The report shall include: **Report.**

(a) The direction in which the specimen was taken, whether lengthwise or crosswise of the sheet.
(b) The thickness and width of each specimen in inches or centimeters.
(c) The breaking load of each specimen, in pounds or kilograms.
(d) The tensile strength of each specimen, in pounds per square inch or in kilograms per square centimeter.
(e) The location and nature of the fracture.
(f) The modulus of elasticity, if determined.
(g) The room temperature.

II. TRANSVERSE STRENGTH

(*A*) *For Materials ½ in. Thick or Over*[1]

Apparatus. 11. (*a*) Any standard type of testing machine may be used. The machine shall have an accuracy of at least 1 per cent of the lowest load for which it is used.

(*b*) The distance between points of support shall be 4 in. for specimens ½ in. in thickness and proportionately longer for greater thicknesses. The supports shall have the contact edges rounded to a radius of ⅛ in. The load shall be applied midway between the supports by a pressure piece, the bearing edge of which shall be rounded to a radius of ⅛ in.

Specimen. 12. The test specimen shall be 5 in. in length, ½ in. in width and ½ in. in thickness, for sheets ½ in. in thickness, and for thicker sheets it shall be the full thickness of the sheet with width and length increased in proportion.

Procedure. 13. The specimens shall be tested as follows:

(*a*) Five specimens cut lengthwise of sheet, tested flatwise.
(*b*) Five specimens cut lengthwise of sheet, tested edgewise.
(*c*) Five specimens cut crosswise of sheet, tested flatwise.
(*d*) Five specimens cut crosswise of sheet, tested edgewise.

Temperature of Tests. 14. All tests shall be made at normal room temperature of about 20° C. (68° F.).

Speed of Testing Machine. 15. The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced, but shall not exceed 0.05 in. per minute when the machine is running idle.

Report. 16. The report shall include:

(*a*) The directions of cutting and loading of the specimen as specified in Section 13.

(*b*) The thickness and width of each specimen in inches or millimeters.

(*c*) The breaking load of each specimen in pounds or kilograms.

(*d*) The maximum fiber stress in pounds per square inch or kilograms per square centimeter calculated from the formula:

$$S = \frac{3}{2}\frac{Pl}{bd^2}$$

where S = maximum fiber stress;
P = breaking load in pounds or kilograms;

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[1] A method of test for thinner materials is being considered.

l = distance between supports in inches or centimeters;

b = width of specimen in inches or centimeters;

d = depth of specimen in inches or centimeters.

(*e*) The room temperature.

(*f*) The deflection at the center in inches or millimeters at a beam load corresponding to a calculated maximum fiber stress of 10,000 lb. per sq. in. (705 kg. per sq. cm.), if determined.

III. DIELECTRIC STRENGTH

17. The dielectric strength shall be determined in accordance with the Tentative Methods of Testing Sheet and Tape Insulating Materials for Dielectric Strength (Serial Designation: D 149 - 26 T) of the American Society for Testing Materials.[1]

IV. PHASE DIFFERENCE (POWER FACTOR) AND DIELECTRIC CONSTANT AT RADIO FREQUENCIES

18. The phase difference and dielectric constant shall be determined in accordance with the Tentative Methods of Testing Electrical Insulating Materials for Phase Difference (Power Factor) and Dielectric Constant at Radio Frequencies (Serial Designation: D 150 - 23 T) of the American Society for Testing Materials.[2]

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[1] See p. 1029.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 822 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 828.

TENTATIVE METHODS OF TESTING INSULATING MATERIALS FOR RESISTANCE TO IMPACT[1]

Serial Designation: D 256 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope.

1. (*a*) These methods are intended to determine the relative toughness of insulating materials as indicated by the notched bar impact test.

(*b*) The Charpy and Izod type of test are equally suited to tests of these materials and the specimen may be broken either as a simple end-supported beam in accordance with Section 4 (*a*) or as a cantilever beam in accordance with Section 5 (*a*).

I. APPARATUS

Apparatus.

2. (*a*) The machine used for the test shall be of the pendulum type, of rigid construction, with a sensitivity of 0.01 ft-lb. or better for values of impact strength of 1 ft-lb. or less. Accurate correction shall be made for friction and windage losses.

(*b*) The dimensions of the machine shall be such that the center of percussion of the tup is at, or very slightly above the point of impact. The point of impact of the Charpy tup shall be taken as the point on the striking edge corresponding to the center line of the specimen.

(*c*) The pendulum shall be released from such a position that the linear velocity of the striking edge (point of impact) at the instant of impact shall be 11.3 ft. per second, which is that corresponding to an initial elevation of the striking edge of 2 ft.

(*d*) Means shall be provided for determing the energy absorbed in breaking the specimen by the subtraction of the true energy remaining in the pendulum after breaking the specimen from the energy of the blow struck.

(*e*) The manner of supporting the specimen and striking the blow shall be in accordance with Sections 5 and 6.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

II. TEST SPECIMEN

Specimen.

3. (*a*) The simple beam specimen shall be in accordance with Fig. 1.

(*b*) The cantilever specimen shall be in accordance with Fig. 2.

(*c*) The notch may be molded, milled or filed, provided the bottom of the resulting notch is smooth, regular and free from scratches.

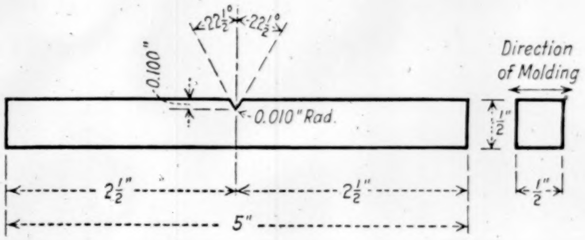

FIG. 1.—Charpy Impact Test Specimen.

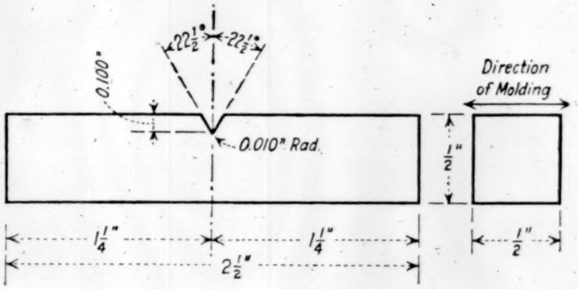

FIG. 2.—Izod Impact Test Specimen.

III. METHOD

(*A*) *End-Supported Beam Method.*

Method.

4. (*a*) Five specimens shall be broken for each test.

(*b*) The specimen shall be supported on two steel blocks with corners rounded to a radius of $\frac{1}{8}$ in. with the points of support 4 in. apart. The blow shall be struck at the center point on the side opposite the notch, the striker being tapered to have an included angle of 45 deg. with the striking edge rounded to a radius of $\frac{1}{8}$ in.

(*B*) *Cantilever Beam Method.*

5. (*a*) Five specimens shall be broken for each test.

(*b*) The specimen shall be rigidly clamped in a vertical position with the center line of the notch on the level of the top of the clamping surfaces and shall be struck on the notched side at a point 0.866 in above the center line of the notch. The edges of the supporting surfaces shall be sharp 90-deg. angles. The striking edge shall be the unrounded edge formed by the intersection of a surface inclined away from the specimen at an angle of 5 deg. at the instant of impact and another surface perpendicular to the specimen at the instant of impact.

NOTE.—It is recommended that a templet be used to locate the specimen in the jaws as specified.

Report. 6. The report of the test shall include the following:

(*a*) A statement indicating the type of test used.

(*b*) The average and minimum values of the energy absorbed in breaking the specimen, expressed in foot pounds and decimals of a foot pound.

TENTATIVE METHODS OF TEST
FOR
SURFACE RESISTIVITY AND VOLUME RESISTIVITY OF SOLID INSULATING MATERIALS[1]

Serial Designation: D 257 - 26 T.

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926.

I. DEFINITIONS

Definitions.

1. (*a*) *Insulation Resistance.*—The insulation resistance between any two electrodes which are fastened to or imbedded in an insulating material is defined as the ratio of the voltage applied to the electrode to the total current which flows between the electrodes. This total current may consist of two parts, that which flows through the volume of the material and that which flows through a surface layer.

Note.—The surface layer is any layer on the surface of an insulator in which the resistivity is different from that of the body of the material. The most common cause of such a layer is moisture which has been deposited on the material from the surrounding air. Insulating materials may be divided into three classes with respect to deposited moisture:

1. Materials which are not wetted by water. In the case of such materials the deposited moisture does not spread over the surface so that there is no true surface layer. Sulfur, paraffin, and the waxes are examples of such materials.

2. Materials which are wetted by water but which do not absorb it. In the case of these materials, the deposited moisture spreads over the surface forming a distinct surface layer. Examples of such materials are glass, quartz, amber, hard rubber, glazed porcelain, and slate. For many of these materials the resistivity of the water in the film is only one billionth part (10^{-9}) of the resistivity of the material. Hence, a film of water of a submicroscopic thickness which is often deposited on an insulator may conduct more current than flows through the body of the specimen.

3. Materials which absorb water. With these materials, there is no true surface layer, since deposited water is absorbed into the material. If the absorption takes place slowly, there may be a gradual gradation of properties on passing from the surface to the interior. Such materials do not have a true surface layer, since the change in resistivity is continuous. Examples of these materials are wood, paper, unglazed porcelain, and many molded and laminated compounds. This class includes a large part of the commercial insulating materials.

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[1] Criticisms of these Tentative Methods are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

(*b*) *Volume Resistance.*—The volume resistance between any two electrodes is the ratio of the electromotive force applied to the current which flows through the volume of the insulating material.

(*c*) *Surface Resistance.*—The surface resistance between any two electrodes is the ratio of the electromotive force applied to the electrodes to the current which flows through the surface layer.

(*d*) *Volume Resistivity.*—The volume resistivity is the resistance between two electrodes which cover opposite faces of a centimeter cube provided there is no surface layer or that the resistance of the surface layer is so high that no appreciable part of the current flows through it.

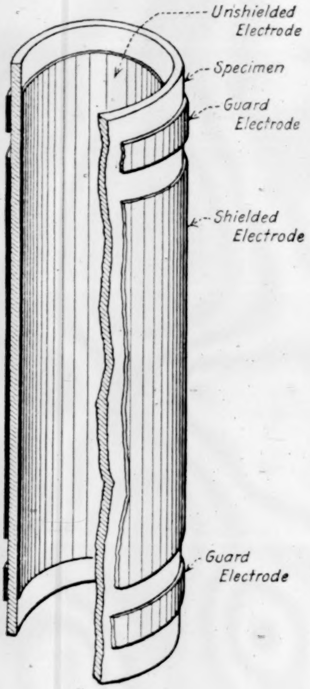

FIG. 1.

(*e*) *Surface Resistivity.*—Surface resistivity is four times the resistance between two electrodes covering opposite faces of a cube when the volume resistance is so high that practically all of the current flows through the surface layers. This is equivalent to defining surface resistivity as the resistance between two opposite edges of a square of the surface layer.

II. SHAPE OF SPECIMEN AND TYPE OF ELECTRODES

2. The specimen shall be either in the form of a flat plate or of a tube. The material of the electrode is unimportant so long as good contact is made between the electrode and the insulating material. For a flat plate, mercury electrodes are very satisfactory though solid metal electrodes are often more convenient, and are satisfactory provided they make good contact. With a tube, a metal spray or conducting paint can be used. Conducting paint, however, should not be used on a porous or absorbent material.

Electrodes.

3. *Electrodes to be Used When Both Volume and Surface Resistance are to be Measured.*—When both volume and surface resistance are to be measured, there should be applied to each specimen three electrodes which are designated as the unshielded electrode, the shielded electrode and the guard electrode. The method of applying these by means of a paint or spray to a tube is shown in Fig. 1. In the case of a tube specimen, the guard electrode is in two parts, one at either end of the tube. In the case of a flat specimen, the guard electrode is in the form of a ring surrounding the shielded electrode. In any case, the distance between the shielded electrode and the guard electrode shall be uniform and as large as one centimeter.

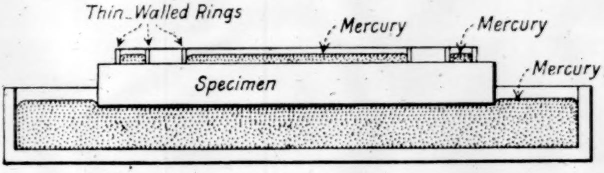

FIG. 2.

Special Electrodes.

4. (*a*) *Guard Electrode Omitted in Measuring Volume Resistance.*—In cases where the surface resistance is known to be high with respect to the volume resistance, the guard electrode may be omitted in measuring volume resistance.

(*b*) *Parallel Strips for Measuring Surface Resistance.*—If the volume resistance is high relative to the surface resistance, metal strips may be used on flat plates for measuring the surface resistance. One method of mounting these is shown in Fig. 3.

(*c*) *Disk Electrodes for Measuring Insulation Resistance.*—Disk electrodes, as shown in Fig. 4, can often be advantageously used to measure insulation resistance where it is not necessary or not possible to separate it into volume and surface resistance. They can also be used to measure surface resistance under the same conditions as given in Paragraph (*b*).

III. APPARATUS

5. The apparatus required is either a megger or the following list of apparatus: a source of constant potential, a galvanometer with suitable shunts, a calibrating resistance, reversing switches and keys and if very high resistances are to be measured, a condenser. The potential can be secured from a dry or storage battery. For most measurements, from 100 to 200 volts is desirable. The galvanometer should have a high-current sensitivity, and will therefore have a high resistance. A sensitivity of 10^{-10} amperes per centimeter with scale at a meter distance is desirable. The most convenient shunt is the type known as a universal shunt whereby the current through the galvanometer can be changed by powers of 10 without changing its damping. The calibrating resistance should be at least 100,000 ohms and preferably 1 megohm or more. All switches and keys shall be mounted on high grade insulating material. Paraffin is recommended

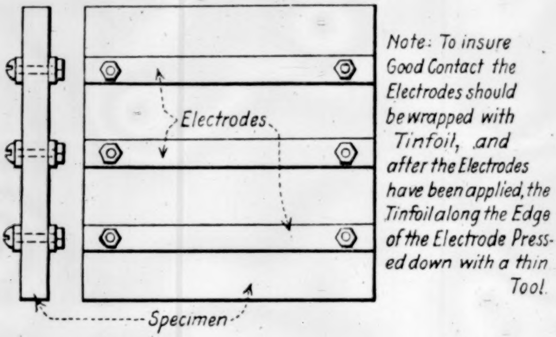
Electrodes
Specimen
Note: To insure Good Contact the Electrodes should be wrapped with Tinfoil, and after the Electrodes have been applied, the Tinfoil along the Edge of the Electrode Pressed down with a thin Tool.

FIG. 3.

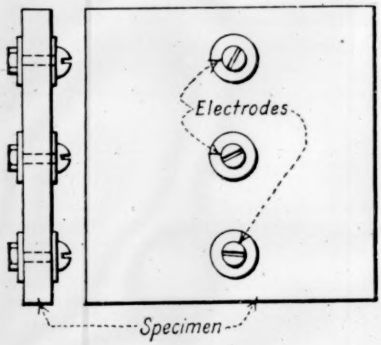
Electrodes
Specimen

FIG. 4.

wherever it can be used. The condenser should have high insulation resistance and reasonably small absorption. Its capacitance should be greater than a thousandth microfarad and preferably greater than a tenth microfarad. A well insulated air or mica condenser is satisfactory and even a good quality paper condenser can be used.

NOTE.—The apparatus herein described will measure resistances as high as 10^{14} ohms. For higher resistances there must be observed special precautions such as the elimination of the conductivity of the surrounding air. A quadrant electrometer is often employed for measuring the extremely small currents which flow through a very high resistance. A method of using such an instrument is described in U. S. Bureau of Standards *Scientific Paper No. 234.*

IV. MEASUREMENTS

Measurements.

6 The following measurements shall be made when both volume and surface resistance are to determined:

(*a*) Area of the shielded electrode.

(*b*) Distance between shielded electrode and guard electrode.

(*c*) The insulation resistance between the shielded electrode and unshielded electrode when the guard electrode is connected to the unshielded electrode.

(*d*) The volume resistance which is the resistance between the shielded electrode and the unshielded electrode when the guard electrode is kept at the same potential as the shielded electrode.

Measurements with Special Electrodes.

7. With all special electrodes, the size and distance apart of the electrodes and the insulation resistance between these electrodes shall be measured.

Measurement of Resistance.

8. *Methods of Measuring Resistance.*—For approximate measurements, a megger having a guard terminal can be used provided the resistances lie within the range of this instrument. The volume resistance shall first be measured, in which case the guard terminal is connected to the guard electrode with the unshielded electrode grounded. The insulation resistance shall then be measured with the guard electrode connected to the unshielded electrode, the guard terminal of the megger being disconnected.

A more accurate method of measuring the resistance is by means of a galvanometer which is used as an ammeter. This galvanometer should have a suitable shunt for increasing its range. If the resistances are too high to be measured directly by the use of the galvanometer, a leakage method employing an auxiliary condenser can be used to increase the range of resistance that can be measured.

In Fig. 5 is shown a diagram of connections from which it will be seen that it is only necessary to throw the switches to use it for measuring either the volume resistance or the insulation resistance of specimens of the type shown in Figs. 1 and 2. The procedure for measuring the volume resistance is as follows: With the galvanometer switch at *B*, with the guard switch at *C*, and with the universal shunt set at a low ratio (say, 1:10,000), close the reversing switch in one direction and then close the key K_1. Increase the ratio of the universal shunt until a readable deflection is obtained on the galvanometer. Read the galvanometer deflection one minute after closing the reversing switch. Repeat measurement with the reversing switch closed in the opposite direction. If no appreciable deflection is obtained when the universal shunt ratio is 1:1, the resistance is too large to be measured by the galvanometer directly.

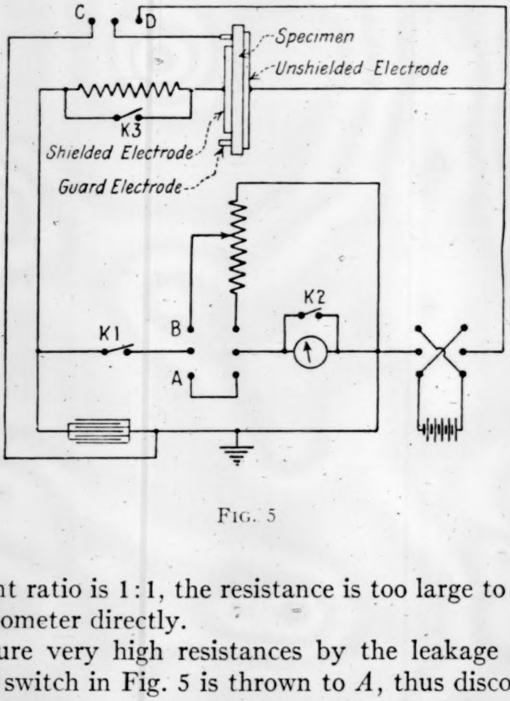

FIG. 5

To measure very high resistances by the leakage method, the galvanometer switch in Fig. 5 is thrown to *A*, thus disconnecting the universal shunt. After closing the reversing switch in one direction, the key K_2 is closed before key K_1 in order that the charging current which flows onto the specimen will not pass through the galvanometer. The key K_1 is then opened at a time which is noted. At some later time, which should not exceed three minutes, key K_1 is closed, discharging the condenser through the galvanometer. The ballistic deflection of the galvanometer is read. The measurements should be repeated with the reversing switch closed in the opposite direction.

If no deflection is obtained with a leakage time of three minutes, the resistance is too high to be measured by the galvanometer.

For measuring insulation resistance, the connections are the same as for measuring volume resistance, except that the guard switch is closed at *D*. The procedure is the same as for measuring volume resistance.

Precautions.

9. *Precautions to be Observed in Measuring Resistance.*—In mounting the specimens for measurement, it is important that there shall be no conduction paths between the electrodes except those through the specimen. For example, the specimens shown in Figs. 3 and 4 should be held by one or both edges so that no one of the electrodes touches the supports.

In measuring high resistances by the setup shown in Fig. 5, it is important that all parts of the apparatus which are connected between the grounded sides of the battery and the shielded electrode shall be very well insulated. In order to test whether the insulation is sufficient, the current through the galvanometer should be negligible when the specimen is disconnected and the galvanometer and attached apparatus is maintained at a potential above ground, which is as high as that of this part of the circuit when the measurements of the resistance are being made. For this test, it is generally sufficient to replace the storage battery by a source of electromotive force having about one one-hundredth of the voltage of the storage battery. The ground is then changed to the opposite side of the battery so that it is connected to the lead going to the unshielded electrode. The circuit is opened at the shielded electrode. With the key K_1 closed the current through the galvanometer should be less than 10 per cent of the current which flows through the specimen during measurement.

In measuring the volume resistance, it is important that there shall be no current flow between the shielded electrode and the guard electrode. This requires that the shielded electrode and the guard electrode shall at all times be at so nearly the same potential that the current flow between them is negligible. The exactness at which these electrodes must be kept at the same potential will depend on the resistance between them as compared with the resistance of the specimen. In order to test this, the key K_3 should be arranged to short circuit the calibrating resistance which is connected to the shielded electrode. With the direct deflection method, the galvanometer reading should be the same with this key open and closed, unless the resistance of the specimen is of the same order of magnitude as the calibrating resistance. When using the condenser method, two different times can be used. With the longer time there is a greater potential difference between the shielded electrode and the guard electrode. If there is an appreciable current flow, the resistances computed by the two different times will be different.

With specimens in a high humidity atmosphere, the electrolytic action of the film of moisture at the metallic edges of the guard electrode and shielded electrode may produce an electromotive force. This will tend to send a current through the galvanometer. To test for this, it is only necessary to close the key K_1 with the galvanometer switch at B and the battery switch open. If the electromotive force is of importance, there will be a deflection of the galvanometer with the shunt set at the ratio used in making the measurement. No satisfactory readings can be made if this electromotive force gives an appreciable current. The only remedy is to use new electrodes.

V. CALCULATIONS

Calculations of Resistance.

10. If the calibrating resistance has a sufficiently high value, the resistance of a specimen, which can be measured by direct deflection, can be easily compared with the calibrating resistance. When measuring the specimen, call the shunt ratio s and the galvanometer deflection d. Then open the guard switch and connect the shielded electrode to the unshielded electrode, thus short-circuiting the specimen. With the key K_1 closed, read the galvanometer deflection D and the shunt ratio S. Then, if the calibrating resistance has a value M, the measured resistance (designated R for volume resistance and R' for surface resistance) is given by the formula

$$R = M \,.\, \frac{D}{d} \,.\, \frac{S}{s}$$

If the calibrating resistance is so small that the battery used in the measurements will give too large a deflection of the galvanometer with the smallest shunt ratio, then it is necessary to calibrate by means of a low voltage battery. The same measurements should be made as in the previous case, but now it is necessary to know the voltage of the calibrating battery E and of the measuring battery e. Then

$$R = M \,.\, \frac{D}{d} \,.\, \frac{s}{S} \,.\, \frac{e}{E}$$

When using the leakage method, the current i through the specimen is so nearly uniform during the time that the key K_1 is open, that the average value may be taken. Then $i = q/t$, where q is the quantity that collects on the condenser in time t. When discharged through the galvanometer, this quantity gives a ballistic deflection d. Hence, if the electromotive force of the battery is e,

$$R = \frac{e}{i} = \frac{et}{q} = \frac{et}{kd}$$

where k is the ballistic constant of the galvanometer.

To determine k, a known quantity Q is discharged through the galvanometer. To obtain Q, a condenser of capacitance C is charged with a cell of voltage E. Then $Q = CE$. This quantity is discharged through the galvanometer giving a deflection D. It follows that $k = \frac{Q}{D} = \frac{CE}{D}\cdot$ This value of k can then be used in the above formula to determine R.

Computations of Resistivities.

11. (*a*) *Volume Resitivity.*—The volume resisitivity ρ is calculated from the formula:

$$\rho = \frac{R\,A}{l}$$

where

R = volume resistance;
A = the area of the shielded electrode;
l = average thickness of the specimen.

Theoretically, certain corrections should be made to this formula For instance, for specimens in the form of tubes, the exact solution would consider that the lines of flow are the radii of circles. This results in a logarithmic formula for the resistivity. However, by suitable expansion, the above formula gives the first approximation which is sufficient for this work. Also, this formula assumes that the lines of flow are straight from the edge of the shielded electrode to the unshielded electrode. This is not the case but the edge correction is negligible.

(*b*) *Surface Resistivity.*—First obtain the value for the surface resistance. If the volume resistivity of the specimen is so high that it was possible to use the specimens shown in Figs. 3 and 4, the surface resistance has been measured directly. If the leakage and volume resistance have been measured by means of either of the specimens shown in Figs. 1 and 2, then the surface resistance can be calculated by the formula:

$$\frac{1}{R'} = \frac{1}{S} - \frac{1}{R} \text{ or } R' = \frac{R\,S}{R - S}$$

where

R' is the surface resistance;
S is the insulation resistance;
R is the volume resistance.

Unless R is at least 10 per cent greater than S, the value of R' shall be considered infinite, indicating no surface layer.

The surface resistivity σ is given by the formula:

$$\sigma = \frac{R' b}{l}$$

where l is the distance between the electrodes and b the average length of the electrodes. In case the electrodes are concentric circles on the same side, as in the case of the flat specimen, as shown in Fig. 2, the length b is the mean of the circumference of the shielded electrode and of the inner edge of the guard electrode.

In the case of the cylindrical specimen shown in Fig. 1, l is the average distance between the shielded electrode and each of the guard electrodes, while b is twice the circumference of the cylinder.

If the electrodes are strips on a flat sheet, as shown in Fig. 3, l is the distance between the strips and b their length. In this case, however, b should be at least 10 times l in order that the correction for the end of the electrodes will be so small that it may be neglected.

In case the electrodes are disks of equal size as shown in Fig. 4, the surface resistivity can be calculated from the formula:

$$\sigma = \frac{\pi R'}{\log_n \left[\frac{s}{2a} + \sqrt{\left(\frac{s}{2a}\right)^2 - 1} \right]}$$

where s is the distance between the centers of the disks and a is their radius. If s has a value between $3a$ and $4a$, then the approximate formula:

$$\sigma = \frac{\pi}{2} \frac{R' (s - a)}{s + a}$$

may be used.

VI. METHOD OF CONTROLLING HUMIDITY

12. Measurements of surface resistance shall be made only on specimens which have been kept for at least 48 hours in air which is

at a definite humidity. Measurement of the insulation resistance of absorbing materials shall be made only on specimens which have been kept for 96 hours in air at a definite humidity. In either case the specimen shall be kept undisturbed in air at this humidity during measurements. The humidity can be readily maintained at any desired point by using an air-tight chamber in which a sulfuric acid - water mixture is exposed. The volume of the acid mixture should be at least one-fiftieth of the volume of the chamber. The container for the mixture shall be an open vessel of such size that the areas of the exposed liquid is at least three times as large as one side of a cube which would hold the required acid mixture. The density of the sulfuric acid - water mixture to give any desired humidity is shown by the curve in Fig. 6. No material which absorbs moisture, except those being tested, should be allowed in the chamber. Provision shall be made for circulating the air and for maintaining the temperature constant. In case a lamp is placed inside the chamber, the specimens should be shielded from direct radiation. A desiccator can be used for a constant humidity chamber provided it can be kept where the temperature is constant. The measurements shall be made without removing the specimen from the chamber. To make this measurement,

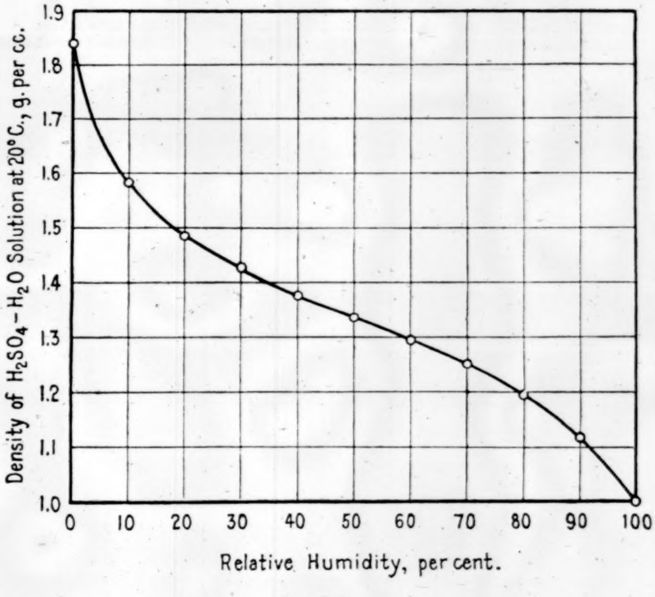

FIG. 6.

highly insulated leads shall pass through the walls of the chamber. This can be accomplished, even if the humidity is very high, by cutting holes in the walls at least 2 cm. ($\frac{3}{4}$ in.) in diameter, closing them with stoppers of paraffin or sulfur, and bringing out leads through the centers of these stoppers.

VII. LAMINATED MATERIALS

13. In the case of laminated materials, both the surface and volume resistivities will depend on the direction of current flow. For a complete test, the volume resistance of laminated materials must be measured both along and across the laminations. Likewise the surface resistance must be measured between three sets of electrodes, one on a surface parallel to the laminations and two on a surface perpendicular to the laminations. The electrodes to be used on the surface parallel to the laminations can be disks, parallel strips, or concentric circles. The two sets of electrodes to be used on the surface perpendicular to the laminations shall be strips, the edges of one set being parallel to the laminations and the edges of the other set perpendicular to the laminations.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES AND TEST METHODS FOR RAYON[1]

Serial Designation: D 258 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1926

DEFINITIONS

1. (*a*) *Rayon* (formerly known as artificial silk). A generic term for filaments made from various solutions of modified cellulose by pressing or drawing the cellulose solution through an orifice, and solidifying it in the form of a filament, or filaments, by means of some precipitating medium.

(*b*) *Rayon Yarns.*—Yarn composed of more than one continuous rayon filament.

(*c*) *Spun Rayon.*—Yarn made from cut rayon filaments, the cut filaments being twisted and drawn out into a yarn by usual spinning processes.

Classification.

2. (*a*) *Nitro-Cellulose Rayon* (Chardonnet).—Filaments composed of a regenerated or denitrated cellulose which has been coagulated or solidified from a solution of nitrated cellulose.

(*b*) *Viscose Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose zanthate.

(*c*) *Cuprammonium Rayon.*—Filaments composed of a regenerated cellulose which has been coagulated or solidified from a solution of cellulose in ammoniacal copper oxide.

(*d*) *Cellulose-Acetate Rayon.*—Filaments composed of an acetic ester of cellulose which has been coagulated or solidified from its solution.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. K. B. Cook, Secretary of Committee D-13 on Textile Materials, United States Rubber Co., 451 S. Jefferson St., Orange, N. J.

IDENTIFICATION

3. Any rayon tested by these methods shall be in the bleached or unbleached state and shall be free from oil or other foreign substances.

I. TO DISTINGUISH CELLULOSE-ACETATE FROM ALL OTHER RAYONS

4. The fibers shall be twisted to a tight wad and cautiously approached to a match flame.

(*a*) Cellulose-acetate rayons "melt" or "fuse" and burn more slowly than other rayons, and harden at once into a brittle substance, globular in appearance.

(*b*) Viscose, nitro-cellulose and cuprammonium rayons all burn like cotton, that is, with no odor and leaving very little ash.

5. Cellulose-acetate is readily soluble in pure acetone in concentrations of not over 1 per cent. This serves as a confirmatory means of differentiating cellulose-acetate rayons from other rayons which are not soluble in this solution.

II. TO DISTINGUISH NITRO-CELLULOSE RAYON FROM VISCOSE AND CUPRAMMONIUM RAYONS

6. The yarn shall be moistened with a solution consisting of 1 per cent of diphenylamine in concentrated sulfuric acid (sp. gr. 1.84).

(*a*) Nitro-cellulose rayons assume immediately a deep blue color. The fibers dissolve rapidly to a blue solution.

(*b*) Viscose and cuprammonium rayons are not colored blue and dissolve more slowly.

III. TO DISTINGUISH CUPRAMMONIUM RAYON FROM VISCOSE RAYON

7. The yarn shall be immersed for one minute in a boiling solution consisting of 1 per cent of silver nitrate, 4 per cent of sodium thiosulfate and 4 per cent of sodium hydroxide.

(*a*) Cuprammonium rayon will remain unstained.

(*b*) Viscose rayon will be stained a brown or reddish brown color. This reaction will also produce a brown stain on nitrocellulose rayon.

NOTE.—*Preparation of Test Solution.*—Dissolve the silver nitrate and sodium thiosulfate separately. Add the first to the second and the cloudiness will disappear. Add the previously dissolved sodium hydroxide. Make up to correct volume, bring to a boil, and filter.

TOLERANCES

IV. SIZE OR YARN NUMBER (DENIER)

8. The denier of a yarn is the weight in grams of 9000 meters.

Size of Rayon Yarn.

9. (*a*) The average size or denier of each skein as supplied by the seller either bleached or unbleached, as found by test, shall not vary more than 10 per cent above or below the specified size or denier.

(*b*) The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of rayon yarn in the singles, either bleached or unbleached, as found by test shall not vary more than 5 per cent above or below the specified size.

Size of Spun Rayon Yarn.

10. The average size or denier of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of spun rayon yarn in the singles, either bleached or unbleached, as found by test, shall not vary more than 5 per cent above or below the specified size.

V. TWIST AND DIRECTION OF TWIST

Definition.

11. *Direction of Twist.*—The yarn has right-hand or regular twist if, when it is held vertical, the spirals or twist are seen to incline upward in a right-hand direction, and left-hand or reverse twist when the spirals or twist are seen to incline upwards in a left-hand direction.

12. The average twist of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn shall not vary beyond the following specified limits:

TURNS PER INCH	ALLOWABLE VARIATIONS
Under 7½	± 25 per cent
7½ to 10	± 15 per cent
Over 10	± 5 per cent

VI. STRENGTH

13. (*a*) The average tensile strength of each case of skeins, tubes, spools, cops, pirns, cones, or a beam warp of yarn in the singles, or plied, either bleached or unbleached, as found by test, shall not be less than the specified strength.

(*b*) Ultimate strength, or strength at the highest yield point, may be specified.

TEST METHODS

VII. SIZE OR YARN NUMBER (DENIER)

(*A*) *Preferred Method*

14. The number or denier shall be determined (except when the rayon is on beams) from skeins which have been prepared, reeled and weighed in an atmosphere, kept in rapid motion by an electric fan, of

65 per cent relative humidity and 70° F. (21° C.) after the spools, cops, tubes, cones, skeins, or other packages from which the test skeins are to be reeled have been conditioned in this atmosphere for three hours when in skeins, and twelve hours when in any of the other forms.

15. Any reel having a perimeter of 112.5 cm. may be used. (See note.) For yarns in skein form, a speed of 100 to 150 r. p. m. shall be used. For yarns on spools, cops, tubes or cones, the yarn shall be drawn off over end and a speed of 200 to 300 r. p. m. of the reel shall be used. The tension on the yarn shall not be heavier than is necessary to lay the yarn smoothly on the reel at the specified speed. The skeins shall be weighed separately on a balance which shall be accurate to 0.25 per cent of the average weight of one skein.

16. Two skeins of 200 turns each from each of 10 spools, cops, tubes, cones or skeins, from one case out of every 10 cases shall be made, and the average of these 20 tests shall be the size or denier.

17. Rayon received on beams shall be tested as specified.

18. The size or yarn number in denier is calculated as follows:

$$\text{Size or yarn number} = \text{Weight of 225-meter skein in grams} \times 40$$

19. The yardage per pound of rayon of any given denier may be calculated by the following formula:

$$\text{Yards per pound of rayon} = \frac{4{,}464{,}528}{\text{Given denier}} \text{ (yards per pound of one denier yarn)}$$

(*B*) *Alternate Method*

20. The winding and weighing of the skeins shall be carried out under prevailing atmospheric conditions, following in all other respects the procedure outlined in Sections 14 to 19. The results thus obtained shall be reduced to a common basis of standard moisture regain for the class rayon under test by the following formulas:

(*a*) For nitro-cellulose, viscose and cuprammonium rayons.—

$$\text{Denier corrected to 14.5-per-cent moisture regain} = \frac{\text{Denier} \times 114.5}{(100 + \text{actual percentage of regain})}$$

(*b*) For cellulose-acetate rayons.—

$$\text{Denier corrected to 6.5-per-cent moisture regain} = \frac{\text{Denier} \times 106.5}{(100 + \text{actual percentage of regain})}$$

21. To determine the actual percentage of moisture regain present in the sizing skeins, two groups of three skeins each shall be taken immediately after weighing and the weight of each group recorded. They shall then be placed in two separate baskets in a conditioning

oven and dried to constant weight on a balance sensitive to 0.25 per cent of the average weight of one skein at 105 to 110° C. (221 to 230° F.). The moisture regain of each group shall then be computed as the percentage of the dry weight and the average of these two shall be the actual percentage of moisture regain in the sizing skeins.

NOTE.—In a laboratory which is equipped for testing cotton yarns only, the skeins may be prepared on any reel having a perimeter of $1\frac{1}{2}$ yards. Each skein must contain 200 ends as before.

If a skein of this length is used the yarn number or denier must be calculated by means of the following formulas:

If the weighing is made in grams.—

$$\text{Yarn number or denier} = \frac{\text{Weight of 300-yd. skein in grams} \times 1.64}{0.05 \text{ gram (per denier)}}$$

If the skeins are weighed in grains.—

$$\text{Yarn number or deneir} = \frac{\text{Weight of 300-yd. skein in grains} \times 1.64}{0.7716 \text{ grain (per denier)}}$$

VIII. STRENGTH

(A) *Preferred Method*

22. One skein from each of the ten spools, cops, tubes, cones or skeins drawn for a sample shall be prepared as described in Sections 15 and 16. The number of turns in these strength skeins shall be as specified in Table I. For sizes which require 200 ends, ten of the sizing skeins may be used if desired.

TABLE I

DENIER OF RAYON	NO. OF TURNS IN STRENGTH SKEIN
1 - 50 denier	400
51 - 75 "	200
76 - 120 "	150
121 - 200 "	100
Over 200 "	50

23. After conditioning for at least three hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.) these ten skeins shall be separately broken on an automatic power yarn tester of inclination balanced type of 25 kg. (55 lb.) or 50 kg. (110 lb.) capacities. The lower capacity shall be used until the swing of the pendulum exceeds an angle of 45 deg. from the vertical. When yarns break above this mark the higher capacity of testing machine shall be used.

24. The machine shall be equipped with an automatic charting device to record stretch at any load.

25. Any tendency to friction, backlash, or play in the recording device, lower jaw, or screw, shall be overcome as far as practicable by counter balancing.

Jaws.

26. Clamps for holding the 200-end test skein shall consist of flat metallic jaws. These shall be covered with one layer of rubber tire tape which shall press directly against the specimen. One gripping surface shall be hinged or swiveled and the other shall be rigidly connected to the frame of the jaw. The pressure between the jaws shall be secured by any suitable mechanical device so constructed as to grip the yarns firmly before the testing load is applied and prevent visible slipping during the progress of the test.

27. The initial distance between jaws shall be 10 cm. (4 in.). The skein to be tested shall first be clamped in the upper jaws, spread out evenly so that the ends are parallel, forming a ribbon approximately $\frac{3}{8}$ to $\frac{3}{4}$ in. in width. The rayon shall then be drawn down through the lower jaws and spread out to make a band of equal width, pulled just taut and clamped.

Speed of Jaw.

28. The pulling jaw shall travel at a speed of 6 in. per minute. One test shall be made on each of the 10 skeins prepared as in Section 22 and the average of these 10 tests shall be the strength.

(*B*) *Alternate Method*

29. Five single strands from each of 10 spools, cops, tubes, cones, or skeins, shall be broken after conditioning the skeins for three hours and any other form of package for 12 hours in an atmosphere, kept in rapid motion by an electric fan, of 65 per cent relative humidity and 70° F. (21° C.). A single strand tester of proper capacity with the jaws set 10 in. between grips and having a speed of pulling jaw of 12 in. per minute shall be used.

30. The average of 50 tests shall be the tensile strength.

IX. TWIST

31. The twist shall be determined on any standard twist tester with jaws set 10 in apart. The yarn shall be clamped in the jaws under a definite tension by attaching weights. The tension to be used shall approximate a value to be determined by the following formula:

$$\text{Tension in grams} = \frac{\text{Specified denier}}{30}$$

Example.—The weight for 150 denier rayon would be $\frac{150}{30} = 5$ g.

32. Two tests, from each of five spools, cops, tubes, cones or skeins, shall be made and the average of these ten tests calculated to turns per inch shall be the twist.

X. MOISTURE REGAIN

33. The standard moisture regain of nitro-cellulose, viscose and cuprammonium rayons shall be 14.5 per cent of the dry weight.

34. The standard moisture regain of cellulose-acetate rayons shall be 6.5 per cent of the dry weight.

TENTATIVE SPECIFICATIONS
FOR
TOLERANCES AND TEST METHODS FOR ELECTRICAL SILK AND COTTON TAPES[1]

Serial Designation: D 259 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Scope. 1. These specifications cover the tolerances and test methods for silk and cotton tape used in the electrical industry for purposes of insulation.

TOLERANCES

I. THICKNESS

Thickness. 2. The thickness of the fabric shall not vary from that specified by more than the following amounts:

Thickness, in.	Permissible Variations
Up to and including 0.007	±0.0008 in.
Over 0.007 and including 0.011	±0.001 in.
Over 0.011 and including 0.020	±0.0015 in.

II. WIDTH

Width. 3. The width of the fabric shall not vary from that specified by more than the following amounts:

Nominal Width of Fabric, in.	Permissible Variations
$\frac{1}{2}$	$\pm\frac{1}{32}$ in.
$\frac{3}{4}$	$\pm\frac{1}{32}$ in.
1	$\pm\frac{3}{64}$ in.
$1\frac{1}{4}$	$\pm\frac{3}{64}$ in.
$1\frac{1}{2}$	$\pm\frac{3}{64}$ in.
Above $1\frac{1}{2}$	$\pm\frac{1}{16}$ in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed to Mr. K. B. Cook, Secretary of Committee D-13 on Textile Materials, 451 S. Jefferson St., Orange, N. J.

III. WEIGHT

Weight.

4. The average weight of the fabric shall be calculated in pounds per gross yards and in no case shall the weight exceed the agreed specified weight by more than 3 per cent.

IV. CONSTRUCTION

Construction.

5. The total number of ends shall be not less than specified. The picks per inch shall not vary more than:

±1 pick for tapes counting up to and including 48 per inch;
±2 picks for tapes counting over 48 per inch.

METHODS OF TESTING

V. THICKNESS

Method of Measuring Thickness.

6. The thickness of the fabric may be determined by the use of any accurate dial gage measuring device acceptable to both supplier and user or by the use of micrometers having measuring faces not less than $\frac{7}{16}$ in. in diameter or more than $\frac{1}{2}$ in. in diameter.

Number of Measurements.

7. The range of thickness shall be recorded on the sample used for the weight determination hereinafter described when using an indicating device. When ordinary micrometers are used, at least twenty measurements should be taken on the same sample and the range of thickness recorded.

VI. WIDTH

Method of Measuring Width.

8. The width of the narrow fabric shall be determined by the use of a standard steel scale graduated to read within the degree of accuracy referred to in the table of tolerances. The fabric shall lay flat on a smooth surface at the time of measurement.

Number of Measurements.

9. The same number of measurements are to be made on the same length specimens as in the case of the thickness.

VII. WEIGHT

Weight.

10. The weight of the fabric shall be determined by accurately measuring a sample, not less than 12 yd. in length, either by hand or by the use of any accurate measuring device and then weighing the sample and calculating the weight in pounds per gross yards.

Number of Tests.

11. One weight determination shall be made per gross yards. The average weight of all tape tested shall indicate the average weight of the shipment involved.

VIII. CONSTRUCTION

Ends.

12. The total number of ends shall be determined irrespective of the width of the fabric.

13. The number of picks shall be determined in a length of 1 in. **Picks.**

14. Both the number of ends and number of picks shall be taken as the average of five counts on five different places on the sample. An accepted thread counting magnifying glass shall be used in making these counts. **Number of Tests.**

IX. TENSILE STRENGTH

15. The tensile strength of the tape shall be determined on a testing machine which complies with the Tentative Specifications for Textile Testing Machines (D 76 - 25 T) of the American Society for Testing Materials,[1] and tests shall be made in the direction of warp only. **Tensile Strength.**

16. The specimens shall be tested in full section and the distance between jaws shall be 3 in. **Number of Tests.**

17. At least five strength determinations shall be made and the average of these five tests are to indicate the strength of the roll.

X. NUMBER OF TESTS

18. From each shipment of electrical cotton tape at least three rolls shall be selected and the tests outlined shall be made on each roll. Failure of the first samples selected to conform to the requirements of the specifications will necessitate a selection of the same number of rolls for a second test. **Number of Rolls Tested.**

19. Failure of any of the tape to conform to the requirements of these specifications will make the shipment the subject of complaint and disposition in accordance with the agreement between the supplier and user.

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[1] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 829 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 915.

TENTATIVE DEFINITIONS OF TERMS RELATING TO TEXTILE MATERIALS[1]

Serial Designation: D 123 - 26 T

This is a Tentative Standard only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1921; REVISED, 1922, 1926.

(*A*) *Imperfections*

Thick and Thin Places.—In the case of major defects, places in the fabric where for one inch or more the count varies a specified per cent or over from the specified count.

Thick and Thin Places.—In the case of minor defects, places in the fabric where for less than one inch the count varies a specified per cent or over from the specified count.

Missing Warp (*Yarn or Cord*).—A place in the fabric where a portion of the warp yarn or cord is missing.

Pucker (*Puff or Blister*).—A series in the fabric of six or more tight or slack warp yarns.

Bad Start-up.—A defect in fabric due to faulty starting-up of the loom resulting in removal of filling yarn, usually resulting in chafed or tight and loose warp yarns, thin selvage or excessive bow, or any combination of them.

Knot.—A joining of portions of a full-ply yarn in the fabric by tying.

Slack and Tight Warp or Filling Yarns or Cords.—Yarns or cords having too little or too much tension, respectively.

Slug.—A bunch of lint entangled in the yarn, cord or fabric.

Sewed Yarn.—A yarn in the fabric interwoven by hand.

Corkscrew Twist.—A place in the yarn or cord where an uneven twist gives a corkscrew-like appearance.

Mispick or Broken Pick.—A streak across the width of the fabric caused by a missing or partly missing pick.

Float.—A place in the fabric where warp and filling threads are incorrectly interlaced.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed to Mr. K. B. Cook, Secretary of Committee D-13 on Textile Materials, United States Rubber Co., 451 S. Jefferson St., Orange, N. J.

Kink.—A place in the fabric where a slack strand twists on itself, forming a loop on the yarn or cord.

Reed Mark.—An irregularity in the warp count of fabric due to a sprung reed or other cause.

Split or Chafed Yarn or Cord.—One or more ends of ply yarn or cord broken in the fabric and chafed into a bunch.

Dirty Yarn.—Requires no definition.

Wrong Ply Warp (Yarn or Cord).—Requires no definition.

Wrong Draw.—A streak lengthwise of the fabric where the filling floats over more than one yarn due to a warp yarn having been drawn through the wrong harness.

Oil Spot.—Requires no definition.

Mixed Yarn of Inferior Grade.—Requires no definition.

Irregular Pick.—A place in the fabric where the picks are irregularly spaced.

Smash.—A place in the fabric where the warp, yarns, or cords have been broken due to the shuttle getting caught in the shed during weaving.

Imperfect Selvage.—Tight, loose, cut, broken, weak, or nicked selvage.

Baggy Fabric.—A loose place in the fabric which gives the appearance of a bag or pocket.

Wrong Ply Filling Yarn.—Requires no definition.

Mixed Yarn or Cord.—Requires no definition.

Defective Splice.—A splice having irregular final twist, untrimmed ends or excessive thickness.

(B) *Mechanical Cotton Fabric*

The term "Mechanical Fabric" shall be understood to mean fabric manufactured for use as an intermediate product in the making of some mechanically constructed article.

NOTE.—Mechanical fabrics shall be referred to by the following descriptive nomenclature:

A word or phrase generally descriptive of the appearance of the material, or the use to which it is put.

Weight in ounces per square yard. The words "oz. sq. yd." are to be written after the weight. To avoid confusion in regard to weight of material, it is suggested that immediately succeeding the square yard weight, the weight of the material on whatever basis may have been used previous to the adoption of these standards be inserted in brackets. Table I gives the conversion values of linear yard weight to square yard weight.

Width in inches.

Count, giving first the ends, and second the picks per inch.

Example: Hose Duck, 9 oz. sq. yd. [40 in. 10 oz.], 48 in., 28 by 18.

TABLE I.—CONVERSION TABLE OF LINEAR YARD WEIGHT TO SQUARE YARD WEIGHT OF FABRIC.

Weight, oz.	Width, in.																														
	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	**60**
8	9.60	9.29	9.00	8.73	8.47	8.23	8.00	7.78	7.58	7.38	7.20	7.02	6.86	6.70	6.55	6.40	6.26	6.13	6.00	5.88	5.76	5.65	5.54	5.43	5.33	5.24	5.14	5.05	4.97	4.88	4.80
9	10.80	10.45	10.13	9.82	9.53	9.26	9.00	8.76	8.53	8.31	8.10	7.90	7.71	7.53	7.36	7.20	7.04	6.89	6.75	6.61	6.48	6.35	6.23	6.11	6.00	5.89	5.79	5.68	5.59	5.49	5.40
10	12.00	11.61	11.25	10.91	10.59	10.29	10.00	9.73	9.47	9.23	9.00	8.78	8.57	8.37	8.18	8.00	7.83	7.66	7.50	7.35	7.20	7.06	6.92	6.79	6.67	6.55	6.43	6.32	6.21	6.10	6.00
11	13.20	12.77	12.38	12.00	11.65	11.31	11.00	10.70	10.42	10.15	9.90	9.66	9.43	9.21	9.00	8.80	8.61	8.43	8.25	8.08	7.92	7.76	7.62	7.47	7.33	7.20	7.07	6.95	6.83	6.71	6.60
12	14.40	13.94	13.50	13.09	12.71	12.34	12.00	11.68	11.37	11.08	10.80	10.54	10.29	10.05	9.82	9.60	9.39	9.19	9.00	8.82	8.64	8.47	8.31	8.15	8.00	7.85	7.71	7.58	7.45	7.32	7.20
13	15.60	15.10	14.63	14.18	13.76	13.37	13.00	12.65	12.32	12.00	11.70	11.41	11.14	10.88	10.64	10.40	10.17	9.96	9.75	9.55	9.36	9.18	9.00	8.83	8.67	8.51	8.36	8.21	8.07	7.93	7.80
14	16.80	16.26	15.75	15.27	14.82	14.40	14.00	13.62	13.26	12.92	12.60	12.29	12.00	11.72	11.45	11.20	10.96	10.72	10.50	10.29	10.08	9.88	9.69	9.51	9.33	9.16	9.00	8.84	8.69	8.54	8.40
15	18.00	17.42	16.88	16.36	15.88	15.43	15.00	14.60	14.21	13.85	13.50	13.17	12.86	12.56	12.27	12.00	11.74	11.49	11.25	11.02	10.80	10.59	10.38	10.19	10.00	9.82	9.64	9.47	9.31	9.15	9.00
16	19.20	18.58	18.00	17.45	16.94	16.46	16.00	15.57	15.16	14.77	14.40	14.05	13.71	13.40	13.09	12.80	12.52	12.26	12.00	11.76	11.52	11.29	11.08	10.87	10.67	10.47	10.29	10.11	9.93	9.76	9.60
17	20.40	19.74	19.13	18.56	18.00	17.49	17.00	16.54	16.11	15.69	15.30	14.93	14.57	14.23	13.91	13.60	13.30	13.02	12.75	12.49	12.24	12.00	11.77	11.55	11.33	11.13	10.93	10.74	10.55	10.37	10.20
18	21.60	20.90	20.25	19.64	19.06	18.51	18.00	17.51	17.05	16.62	16.20	15.80	15.43	15.07	14.73	14.40	14.09	13.79	13.50	13.22	12.96	12.71	12.46	12.23	12.00	11.78	11.57	11.37	11.17	10.98	10.80
19	22.80	22.06	21.38	20.73	20.12	19.54	19.00	18.49	18.10	17.54	17.10	16.68	16.29	15.91	15.55	15.20	14.87	14.55	14.25	13.96	13.68	13.41	13.15	12.91	12.67	12.44	12.21	12.00	11.79	11.59	11.40
20	24.00	23.23	22.50	21.82	21.18	20.57	20.00	19.46	18.95	18.46	18.00	17.56	17.14	16.74	16.36	16.00	15.65	15.32	15.00	14.69	14.40	14.12	13.85	13.58	13.33	13.09	12.86	12.63	12.41	12.20	12.00
21	25.20	24.39	23.63	22.91	22.24	21.60	21.00	20.43	19.89	19.38	18.90	18.44	18.00	17.58	17.18	16.80	16.43	16.09	15.75	15.43	15.12	14.82	14.54	14.26	14.00	13.75	13.50	13.26	13.03	12.81	12.60
22	26.40	25.55	24.75	24.00	23.29	22.63	22.00	21.41	20.84	20.31	19.80	19.32	18.86	18.42	18.00	17.60	17.22	16.85	16.50	16.16	15.84	15.53	15.23	14.94	14.67	14.40	14.14	13.89	13.66	13.42	13.20
23	27.60	26.71	25.88	25.09	24.35	23.66	23.00	22.38	21.79	22.23	20.70	20.20	19.71	19.26	18.82	18.40	18.00	17.62	17.25	16.89	16.56	16.24	15.92	15.62	15.33	15.05	14.79	14.53	14.28	14.03	13.80
24	28.80	27.87	27.00	26.18	25.41	24.69	24.00	23.35	22.74	22.15	21.60	21.07	20.57	20.09	19.64	19.20	18.78	18.38	18.00	17.63	17.28	16.94	16.62	16.30	16.00	15.71	15.43	15.16	14.90	14.64	14.40
25	30.00	29.03	28.13	27.27	26.47	25.71	25.00	24.33	23.68	23.08	22.50	21.95	21.43	20.93	20.45	20.00	19.57	19.15	18.75	18.37	18.00	17.65	17.31	16.98	16.67	16.36	16.07	15.79	15.52	15.25	15.00
26	31.20	30.19	29.25	28.36	27.53	26.74	26.00	25.30	24.63	24.00	23.40	22.83	22.29	21.77	21.27	20.80	20.35	19.91	19.50	19.10	18.72	18.35	18.00	17.66	17.33	17.02	16.71	16.42	16.14	15.86	15.60
27	32.40	31.35	30.38	29.45	28.59	27.77	27.00	26.27	25.58	24.92	24.30	23.71	23.14	22.60	22.09	21.60	21.13	20.68	20.25	19.84	19.44	19.06	18.69	18.34	18.00	17.67	17.36	17.05	16.76	16.47	16.20
28	33.60	32.52	31.50	30.55	29.65	28.80	28.00	27.25	26.53	25.85	25.20	24.59	24.00	23.44	22.91	22.40	21.91	21.45	21.00	20.57	20.16	19.76	19.38	19.02	18.67	18.33	18.00	17.68	17.38	17.08	16.80
29	34.80	33.68	32.63	31.64	30.71	29.83	29.00	28.22	27.47	26.77	26.10	25.46	24.86	24.28	23.73	23.20	22.70	22.21	21.75	21.31	20.88	20.47	20.08	19.70	19.33	18.98	18.64	18.32	18.00	17.69	17.40
30	36.00	34.84	33.75	32.73	31.76	30.85	30.00	29.19	28.42	27.69	27.00	26.34	25.71	25.12	24.55	24.00	23.48	22.98	22.50	22.04	21.60	21.18	20.77	20.37	20.00	19.64	19.29	18.95	18.62	18.31	18.00
31	37.20	36.00	34.88	33.82	32.82	31.89	31.00	30.16	29.37	28.62	27.90	27.22	26.57	25.95	25.36	24.80	24.26	23.74	23.25	22.78	22.32	21.88	21.46	21.06	20.67	20.29	19.93	19.58	19.24	18.92	18.60
32	38.40	37.16	36.00	34.91	33.88	32.91	32.00	31.14	30.32	29.54	28.80	28.10	27.43	26.79	26.18	25.60	25.04	24.51	24.00	23.51	23.04	22.59	22.15	21.74	21.33	20.95	20.57	20.21	19.86	19.53	19.20
33	39.60	38.32	37.13	36.00	34.94	33.94	33.00	32.11	31.26	30.46	29.70	28.98	28.29	27.63	27.00	26.40	25.83	25.28	24.75	24.24	23.76	23.29	22.85	22.42	22.00	21.60	21.21	20.84	20.48	20.14	19.80
34	40.80	39.48	38.25	37.09	36.00	34.97	34.00	33.08	32.21	31.38	30.60	29.85	29.14	28.47	27.82	27.20	26.61	26.04	25.50	24.98	24.48	24.00	23.54	23.09	22.67	22.25	21.86	21.47	21.10	20.75	20.40
35	42.00	40.65	39.38	38.18	37.06	36.00	35.00	34.06	33.16	32.31	31.50	30.73	30.00	29.30	28.64	28.00	27.39	26.81	26.25	25.71	25.20	24.71	24.23	23.77	23.33	22.91	22.50	22.11	21.72	21.35	21.00
36	43.20	41.81	40.50	39.27	38.12	37.03	36.00	35.03	34.11	33.23	32.40	31.61	30.86	30.14	29.45	28.80	28.17	27.57	27.00	26.45	25.92	25.41	24.92	24.45	24.00	23.56	23.14	22.74	22.34	21.97	21.60

The following is a partial list of mechanical fabrics in general use:

Tire Builder Fabric.—A square woven fabric having usually 11-ply yarn in both warp and filling.

Tire Cord Fabric.—A fabric consisting of hawser cord yarn in the warp, with single yarn filling at intervals to keep warp threads together.

Hose Duck.—A soft, plain-weave fabric of plied yarns not finer than No. 8, made in weights from 10 to 24 oz. to the 40-in. width. When made of finer yarn than No. 8, it is classed as Special Hose Duck.

Rubber Belt Duck.—A soft, plain-weave fabric of plied yarns not finer than No. 8, weight ranging from 22 to 36 oz. to 42-in. width. When made of finer yarn than No. 8, it is classed as Special Belt Duck.

Balata Belt Duck.—A closely woven fabric made of hard twisted plied yarn usually made in wide widths, the weight being based on the square yard.

Oil Belt Duck.—A closely woven fabric of plied yarns not over No. 8, made in a variety of widths, usually a 32-oz. fabric, the weight being based on the square yard.

Numbered Duck.—A plain woven fabric of plied yarns ranging from coarse to fine numbers, the weight being based on 22-in. width.

Army Duck.—A closely woven fabric of plied yarns, usually ranging between 7 to 12 oz., the weight being based on 28½-in. width.

Single Filled or Flat Duck.—A fabric made of single yarn, plain weave, the weight being based on 29-in. width.

Enameling Duck.—A plain woven fabric with laid warp and plied yarn filling, weight being based on 46½-in. width.

(C) *Cotton Fabrics Other than Mechanical Fabrics*

Twill.—A weave which produces pronounced lines running diagonally across the fabric, some of which are known as follows:

Drills.—A commercial term for a fabric with warp face twill usually made with three harnesses and single yarns.

Alberts.—A commercial term for a fabric of twill weave with filling face usually made with four or five harnesses.

Jeans.—A commercial term for a fabric with warp face twill like a drill but with higher count and finer yarns.

Serge.—A commercial term for a fabric of twill weave made with four harnesses 2 by 2.

Clay.—A commercial term for a fabric of twill weave similar to a serge, but made with six harnesses 3 by 3.

(*D*) *General Definitions*

Standard Atmosphere.—For the purposes of moisture regulation and definition, a standard atmosphere shall be an air condition in which there is a relative humidity of 65 per cent at a temperature of 21° C. (70° F.).

Standard Condition.—Wherever the term "standard condition" is used in reference to the moisture condition of any textile material it shall be understood to mean the condition of the material when it is in moisture equilibrium with a standard atmosphere.

Regain (*Moisture Regain*).—The percentage of moisture present in a textile material calculated on its absolute dry weight.

Standard Regain.—In the case of any specific kind of textile fiber, an agreed or officially adopted percentage allowance of moisture added to the absolute dry weight of the material to determine its standard weight.

Standard Weight.—In the case of a textile material, a weight equal to its absolute dry weight plus its standard regain.

Moisture Content.—The terms moisture, moisture content or percentage of moisture applied to a textile material shall mean the percentage of moisture present in the material calculated on its net weight.

Yarn.—An assemblage of fibers or filaments of animal, mineral, or vegetable origin, either natural or manufactured, twisted or laid together forming a strand or group of strands for use in weaving, knitting, or forming in any manner into textile fabrics.

Cord.—A string or small rope of fibrous material made by twisting together, generally with hard twist, several yarns and used for tying, binding, lacing, etc., and weaving or laying very heavy fabrics.

Thread.—A fine cord composed of two or more yarns twisted together and used for sewing purposes.

Lea.—The division of a hank (840 yd.) of cotton yarn, 120 yd. made up of 80 turns on a standard cotton reel. Also a hank of linen yarn, 300 yd., and used as the basis of the linen yarn count.

Count.—In the case of cotton yarn, the number of 840 yd. hanks contained in one pound (avoirdupois 7000 grains) of the yarn at standard condition.

Ends.—The individual warp yarns running lengthwise of the fabric.

Picks.—The individual weft or filling yarns running across the fabric.

Gage.—In the case of knit goods, the closeness of the wales, that is, the longitudinal row of loops per inch, a measure of the fineness of the fabric. It is expressed by the number of needles in $1\frac{1}{2}$ in.

Plain Weave.—The fabric pattern in which each yarn of the weft passes alternately over and under a yarn of warp.

Twist, Direction of.—In the case of yarn or cord, the yarn or cord has right-hand twist if when it is held vertically the spirals or twists are seen to incline upward in a right-hand direction and has left-hand twist when the spirals or twists are seen to incline upward in a left-hand direction.

In the case of cotton sewing thread, the terms are opposite to those for yarn; the thread has right-hand twist if when it is held vertically the spirals or twists are seen to incline upward in a left-hand direction and left-hand twist if inclined upward in a right-hand direction.

NOTE.—The definitions as here given do not agree in that "direction of twist" is defined in such a way that left-hand twist in case of yarn or cord corresponds to right-hand twist in case of sewing thread. An attempt is being made to harmonize these two conceptions of "direction of twist."

Crimp.—In the case of fabric, the difference in distance between any two points of the yarn as it lies in the fabric, and the same two points after the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points as the yarn lies in the fabric.

NOTE.—"Crimp" is not to be confused with "take-up" which is the difference in distance between any two points on the yarn as it lies in the fabric and the same two points after the yarn has been removed from the fabric and straightened, expressed as a percentage of the distance between the two points after the yarn has been straightened. The threads for the "take-up" test shall be straightened with the same machine that is used for the "crimp" test, but for this test it shall be equipped with an extra scale on the dial, in which case the scale shall be plainly marked "crimp" and "take-up."

Off-Square.—In the case of fabric, the percentage of warp crimp minus the percentage of filling crimp.

TENTATIVE METHOD OF VERIFICATION OF TESTING MACHINES BY MEANS OF AN ELASTIC CALIBRATION BAR[1]

Serial Designation: E 4 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

Issued, 1924; Revised, 1926.

1. In this method the testing machine to be verified is tested by comparing its load indications with the amount of elastic deformation of a calibration bar,[2] the deformation being measured with a delicate strainometer.

2. The calibration bar may be either a bar tested in tension or in compression and it shall be fitted with spherical-seated shackles or with a spherical-seated bearing block to insure as nearly axial loading as is possible. The arrangement shown in Fig. 1 or Fig. 2 is suggested for tension bars and the arrangement shown in Fig. 3 is suggested for compression bars.

3. (*a*) The calibration bar shall be of such size that under the greatest load for which the bar is to be used (called its full load) the stress on any cross-section will not be more than 80 per cent of the elastic limit of the material, as determined in accordance with Method II for the Determination of Elastic Limit as described under the definition of the term "Elastic Limit" of the Tentative Definitions of Terms Relating to Methods of Testing (Serial Designation: E 6 – 25 T) of the American Society for Testing Materials[3] on a test specimen cut from the end of the bar after its final heat treatment.

(*b*) Before the calibration bar is used for verification purposes, it shall be loaded to its full load at least six times, and between successive loadings it shall be heated to a temperature of 100° C. (212° F.) for a period of thirty minutes or shall be allowed to rest for a period of 24 hours. The object of this treatment is to adjust the bar to its bearings and to relieve internal strain.

4. The *loading range* of a calibration bar is the range of indicated loads for which the bar gives results within specified tolerances.

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[1] This Tentative Method, when adopted as standard, will become a part of the present Standard Methods of Verification of Testing Machines (Serial Designation: E 4 – 24), 1924 Book of A.S.T.M. Standards.

Criticisms of this Tentative Method are solicited and should be directed to Mr. H. F. Moore, Chairman of Sub-Committee, of Committee E-1, on Mechanical Testing, University of Illinois, Urbana, Ill.

[2] The term "calibration bar" shall be interpreted to include solid bars, hollow bars, elastic loops and other members whose elastic deformation can be measured.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 879 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 982.

Obviously, the loading range may not include loads either greater than the largest load or less than the smallest load applied in verifying the calibration bar.

5. (*a*) The loading range of a calibration bar shall be determined by verifying its indications by the use of standard weights or by standard weights and proving levers. In verifying the indications of the bar, an initial load of 1 per cent of its full load shall first be applied. All changes of strainometer reading and of applied load shall be reckoned from the readings at this initial load. Successive loads shall be applied, a recommended series of loads being 10, 20, 50 and 100 per cent of the full load of the bar. Such a series shall be applied to the bar at least five times to determine the relation of applied load to strainometer reading, the shackles or bearing blocks being readjusted before each application of the series.

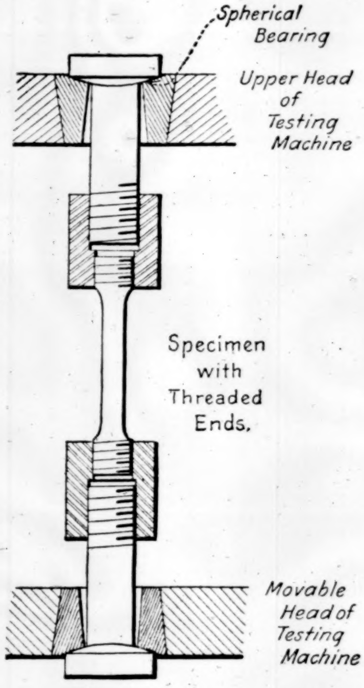
Spherical Bearing
Upper Head of Testing Machine
Specimen with Threaded Ends.
Movable Head of Testing Machine

FIG. 1.

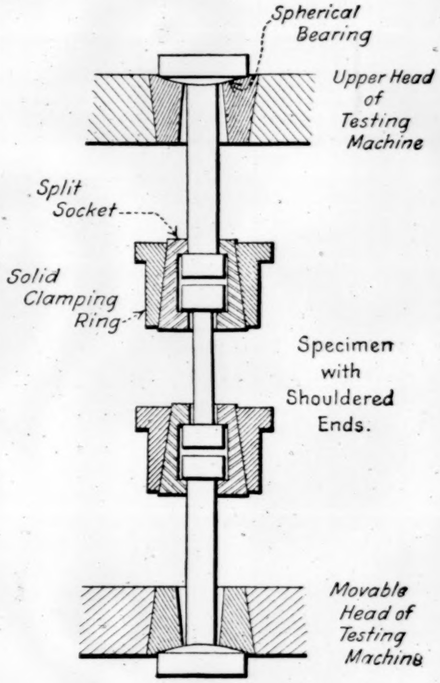
Spherical Bearing
Upper Head of Testing Machine
Split Socket
Solid Clamping Ring
Specimen with Shouldered Ends.
Movable Head of Testing Machine

FIG. 2.

(*b*) The average of the five (or more) strainometer readings obtained in this way shall be taken for each load applied. The average of the differences (taken without regard to algebraic sign) between the individual strainometer readings for any load and the mean reading for that load constitutes the average deviation for that load. The lowest value of load for which the average deviation is not greater than 0.5 per cent of the strain for that load is the lower limit of the loading range of the calibration bar.

NOTE.—If in taking five or more strainometer readings for any load the deviation of any one reading is more than 1 per cent from the mean reading, then this series of five or more readings shall be repeated.

6. The strainometer shall be so designed as to indicate the average elongation or compression of the bar. It shall be sufficiently sensitive to indicate a change of 0.25 per cent of the minimum load in the loading range of the bar. If the strainometer is not permanently attached to the calibration bar, the strainometer shall be removed and replaced for each successive reading taken during the calibration of the bar itself. This, of course, does not mean that the strainometer must be removed for each reading in the regular use of the instrument.

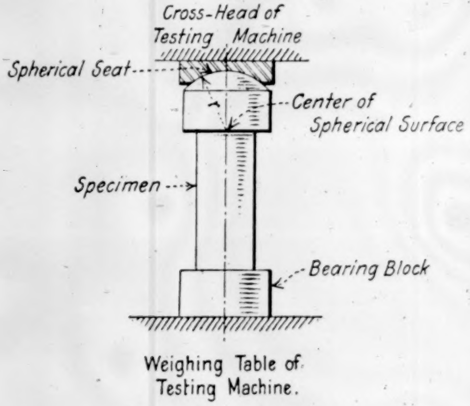

FIG. 3.

7. In using the calibration bar it is important that just previous to taking any reading, including the initial reading of a series, there shall be no reversal in the direction of motion of the indicating mechanism of the strainometer, because such reversal may introduce error due to backlash in the instrument. That is, when taking readings for a series of increasing loads the load should be brought up to each predetermined test load, and when taking readings for a series of decreasing loads the load should be brought down to each predetermined test load.

8. In using a calibration bar made of steel, correction for variation in mean temperature during any calibrations made on different occasions should be made by allowing a diminution of 0.015 per cent ($\frac{15}{1000}$ of 1 per cent) in the modulus of elasticity of steel for each 1° F. increase in temperature. During any calibration with an elastic calibration bar, temperature conditions should be kept as uniform as is possible.

TENTATIVE DEFINITIONS OF TERMS RELATING TO SPECIFIC GRAVITY[1]

Serial Designation: E 12 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

1. *Absolute Specific Gravity* (of solids and liquids).—The ratio of the weight referred to vacuum of a given volume of the material at a stated temperature to the weight referred to vacuum of an equal volume of gas-free distilled water[2] at a stated temperature. It shall be stated thus:

(*a*) When the temperatures of the material and of the water are the *same:*

Absolute Specific Gravity $x°$ C., ...,

where x is the temperature of the material and the water.

(*b*) When the temperatures of the material and of the water are *not the same:*

Absolute Specific Gravity $\frac{x° \text{ C.,}}{y° \text{ C.}}$ ....,

where x is the temperature of the material and y the temperature of the water.

NOTE.—In the interest of standardization and simplification, the first form of statement of specific gravity (*a*) should be employed wherever practicable.

2. *Specific Gravity* (of solids and liquids).—The ratio of the weight in air of a given volume of the material at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature. It shall be stated thus:

(*a*) When the temperatures of the material and of the water are the *same:*

Specific Gravity $x°$ C., ...,

where x is the temperature of the material and the water.

(*b*) When the temperatures of the material and of the water are *not the same:*

Specific Gravity $\frac{x° \text{ C.,}}{y° \text{ C,}}$ ....,

where x is the temperature of the material and y is the temperature of the water.

NOTE.—In the interest of standardization and simplification, the first form of statement of specific gravity (*a*) should be employed wherever practicable.

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[1] Criticisms of these Tentative Definitions are solicted and should be directed to Mr. F. M. Farmer, Chairman of Sub-Committee, of Committee E-8, on Definition of Specific Gravity, Electrical Testing Laboratories, Eightieth Street and East End Ave., New York City.

[2] Distilled water boiled vigorously in vacuum.

3. *Apparent Specific Gravity* (of solids).—The ratio of the weight in air of a given volume of the impermeable portion of a permeable material (that is, the solid matter including its impermeable pores or voids) at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature. It shall be stated thus:

(*a*) When the temperatures of the material and of the water are the *same:*

Apparent Specific Gravity $x°$ C., ...,

where x is the temperature of the material and the water.

(*b*) When the temperatures of the material and of the water are *not the same:*

Apparent Specific Gravity $\frac{x° \text{C.,}}{y° \text{C.}}$ ....,

where x is the temperature of the material and y is the temperature of the water.

NOTE 1.—In scientific circles, specific gravity and density determinations made in air (that is, uncorrected to vacuum) are frequently distinguished by the adjective "apparent." Thus, the specific gravity defined by definition No. 2 would be designated as "apparent specific gravity" and that defined by definition No. 1 as "specific gravity." But in industry, the terminology is more generally in accordance with that given in these definitions.

NOTE 2.—The terms "permeable" and "impermeable" cannot be rigidly defined for general application. The exact meaning in a particular application is the conventional one inferred by the procedure specified for determining the specific gravity of the material in question.

NOTE 3.—In the interest of standardization and simplification, the first form of statement of specific gravity (*a*) should be employed wherever practicable.

4. *Bulk Specific Gravity* (of solids).—The ratio of the weight in air of a given volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the weight in air of an equal volume of distilled water at a stated temperature. It shall be stated thus:

(*a*) When the temperatures of the material and of the water are the *same:*

Bulk Specific Gravity $x°$ C., ...,

where x is the temperature of the material and the water.

(*b*) When the temperatures of the material and of the water are *not the same:*

Bulk Specific Gravity $\frac{x° \text{C.,}}{y° \text{C.}}$ ....,

where x is the temperature of the material and y is the temperature of the water.

NOTE 1.—See Note 2 under "Apparent Specific Gravity."

NOTE 2.—In the interest of standardization and simplification, the first form of statement of specific gravity (*a*) should be employed wherever practicable.

TENTATIVE DEFINITION OF THE TERM SCREEN (SIEVE)[1]

Serial Designation: E 13 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1925; REVISED, 1926.

Screen (Sieve).—A plate or sheet or a woven cloth, with regularly spaced apertures of uniform size, mounted on a suitable frame or holder, for use in separating materials according to size.

NOTE 1.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties, should be taken care of in specifications.

NOTE 2.—In mechanical analysis testing work, the term "sieve" when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are rectangular. The term "screen" when not specifically defined in connection therewith, shall apply to an apparatus in which the apertures are circular.

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[1] Criticisms of this Tentative Definition are solicited and should be directed to Mr. L. R. Ferguson, Chairman of the Sub-Committee, of Committee E-8, on Definitions of Sieve and Screen, Manager, Louisiana Portland Cement Co., 1120 Hibernia Bank Building, New Orleans, La.

TENTATIVE DEFINITION OF THE TERM METALLOGRAPHY[1]

Serial Designation: E 7 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

Metallography.—The study of the constitution and structure of metals and alloys and their relation to the physical and chemical properties.

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[1] Criticisms of this Tentative Definition are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, 967 Harrison Ave., Niagara Falls, N. Y.

TENTATIVE RECOMMENDED PRACTICE
FOR
RADIOGRAPHIC TESTING OF METAL CASTINGS[1]

Serial Designation: E 15 – 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

GENERAL CONSIDERATIONS

On account of their very short wave lengths, X-rays penetrate materials opaque to ordinary light. They are absorbed rapidly by heavy elements much as light is absorbed by fog. If X-radiation is passed through metal that contains cracks, cavities, sand or slag inclusions, the radiation that passes through the defects is absorbed to a less extent than the radiation that passes through the adjacent sound metal. A photographic film placed to intercept the emergent beam will show, on development, regions of greater photographic density that may be definite images of the internal defects. Radiographic tests are concerned with the obtaining of such photographic indications of internal defects. They may be extended to the examination of various other hidden details of gross structure.

There are at present two important fields for application of metal radiography. One of these concerns the development of manufacturing technique in the foundry, the other the final inspection of the manufactured product.

In foundry development work pilot castings are examined, defects are studied and changes made in casting technique to correct the defects. This study leads to a developed technique that may be relied on to produce dependably sound castings, the extent of the elimination of defects depending, to a certain extent, upon the service for which the casting is intended. An important by-product of such application is the education of foundry personnel. Interior defects are present in castings partly because there has been no easy method of detecting their presence and there has been made no particular effort to overcome them because of this fact. Such application to manufacturing methods is probably the most economical use of radiographic tests. But on account of the fact that even with the most fully developed technique accidents or mistakes occur, there is still a possibility for defective castings.

For this reason, and also because very few castings are manufactured at present according to a carefully developed technique, it is important to have a method of testing in final inspection that will reveal internal gross defects and that will not injure the casting. Radiography seems to offer the best solution to this problem. The method is expensive. but in cases where the possible failure of a casting would cause damage far in excess of the cost of the tests radiographic examination becomes a matter of insurance and the question to be answered is often not whether such inspection can be afforded but rather whether it can be afforded not to make it. The rapid development of high-pressure steam installations, high-head hydraulic power, high-pressure oil-cracking systems, higher power locomotives, aerial transportation and various other lines of industrial activity present increasingly numerous cases where such tests may be applied and where sometimes they will be found absolutely necessary.

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[1] Criticisms of this Tentative Recommended Practice are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, 967 Harrison Ave., Niagara Falls, N. Y.

Standards of soundness that must be met by castings in order to pass X-ray inspection cannot be set up at the present time with any degree of fairness to consumer or manufacturer. This fact is due partly to the newness of this method of testing, partly to a lack of sufficient information as to the effects on strength or other properties of various types of defects, but mostly to the fact that each casting is a study in itself. Defects that would be injurious in some castings may not be serious in others and may be even advantageous in peculiar circumstances. It seems that castings must be regarded in this sense as structural units rather than as materials of construction. That they, in fact, have been so regarded is illustrated by the way in which radiographic inspection tests have been handled. That is, revealed defects are usually considered with regard to known stress distribution or other conditions of service and rejections are made where the defects render the casting in question unfit for its particular service. It is probable that in the future, foundries will be able to eliminate the more important casting defects. This will come about through intensive studies of casting technique. When this is accomplished the problem of final inspection will be simplified, but for many important cases will still remain a problem of individual study of individual castings.

DEFECTS THAT MAY BE REVEALED BY X-RAYS

The more common defects found in castings by radiographic tests may be enumerated as follows:

1. Gas cavities:
    - (*a*) Due to gases liberated from the hot metal;
    - (*b*) Due to gases from the mold.
2. Sand inclusions.
3. Slag inclusions.
4. Pipe cavities.
5. Porosity:
    - (*a*) Due to small gas cavities;
    - (*b*) Due to small shrinkage cavities.
6. Cracks.
7. Metal segregations.

Most of these may be eliminated by improved manufacturing methods. Cracks, pipes, and porous sections are sometimes traceable to faulty design.

RADIOGRAPHIC EQUIPMENT

The apparatus needed for radiographic work depends to a certain extent on the nature of the materials to be investigated. For the study of steel castings whose sections do not exceed 3½ in. in thickness, the air-cooled Coolidge X-ray tube rated at 200 KV. and 8 milliamperes has been found satisfactory. A finer focus tube rated at 100 KV. and 10 millamperes is available for steel sections that do not exceed 1½ in. in thickness. The higher powered tube will in general be more satisfactory. The accessory electrical equipment should include a high-tension transformer that will deliver 10 milliamperes at 300 KV. from the secondary, a rectifier for rectifying the output of the transformer, a milliameter for measuring the current across the tube, a standard sphere gap for determining potentials across the tube and a remote control stand containing the operating controls.

The X-ray tube mounted in a flexible support to facilitate manipulation is preferably contained in a lead-lined operating chamber and the control stand in a separate chamber. Intensifying screens are required for metal sections greater than ¾ in. Mounted screens are used where possible, but a supply of unmounted screens of various sizes is desirable. A well-equipped photographic dark room completes the necessary equipment for making radiographs. In addition to the X-ray equipment, the laboratory should be supplied with a good 8 by 10 in. photographic camera and with facilities for handling heavy castings.

RADIOGRAPHIC TECHNIQUE

The procedure in the laboratory is somewhat as follows: A casting to be radiographed is given a superficial examination and areas through which pictures are to be taken are charted. These areas are selected with a view to showing general conditions in the metal and particular conditions in regions that, in service, are subjected to greater stresses or that for other reasons are of particular importance. The selected areas are numbered with white chalk or paint, after which the piece is photographed. The casting is now moved into the operating chamber and the X-ray tube arranged above one of the numbered areas. Lead numerals are placed over the painted ones. These show in the developed picture and serve to identify the areas and to permit exact orientation of the finished negative with the casting so that revealed defects may be charted on the surface of the metal. The special X-ray photographic film is placed in a paper holder or in a metal cassette between intensifying screens and adjusted in as close contact with the metal as possible to intercept the radiation that is to be passed through the selected area. Sheet lead is used to protect the film from all X-radiation, except that passing through the area under investigation. This protection is important. It is a peculiarity of X-radiation that, when it encounters matter, secondary radiation is sent out from the material and this secondary radiation coming from points remote from the target may fog the X-ray film. Secondary radiation is given off by the atoms of the metal under test, but this radiation being weaker than that of the primary beam is absorbed by the metal and does not affect the film except that the radiation from the underside of the metal adjacent to the film is not absorbed, and does produce a certain amount of fog in the negative.

In many cases, pieces to be radiographed vary in thickness of section to such an extent that a proper exposure for the thicker portions would over-expose the portion of the photographic film under the thinner part. This difficulty may be overcome with large castings by first exposing for the thin section after which the thin portion is covered with lead sheet and the exposure continued for the thicker section. This difficulty may be overcome for small objects by immersing them in a liquid whose absorbing power for X-radiation is nearly equal to that of the metal.[1] The exposure is then made through the liquid containing the pieces under investigation. The method is excellent where it can be used. Metal radiography owes very much of its success to intensifying screens. As stated above, matter exposed to X-radiation itself begins to radiate. This secondary radiation may be partly reflected primary radiation and partly radiation of a longer wave length characteristic of the material itself. Also, the greater the intensity of the primary radiation, the greater is the intensity of the secondary. These facts are taken advantage of in the intensifying screen. The special X-ray photographic film, sensitized on both sides, is placed between two thin sheets of material, usually calcium tungstate, that reacts strongly to X-rays. The resultant photographic density is due partly to the direct action of the primary X-ray beam, but mostly to the secondary radiation from the calcium tungstate. On account of the very intimate contact between film and screens there is no tendency for the radiation from the screen material to fog the film, although there is some spreading of the image with resultant loss in definition.

The same effects may be obtained with metal used in the place of the calcium tungstate except that the intensifying factor is much less. The use of lead foil for intensifying screens has some advantage over calcium tungstate. While the intensifying factor is less, the lead absorbs part of the secondary radiation from the under side of the metal being investigated, which, as stated above, tends to cause fog in the negative, and in cutting down fog it increases the contrast in the negative. Lead screens also give finer grained images and consequently sharper definition. These screens have been found particularly useful in examining castings for fine cracks. Unfortunately their intensifying factor is too low for them to be very useful with sections above 2 in. in thickness. A combination of lead and calcium tungstate has been found advantageous for sections up to $2\frac{3}{4}$ in. In this case the lead screen is placed on the side of the film next to the metal to be investigated and the calcium tungstate on the remote side. In as much as one of the present limitations in radiographing thick metal sections is the fogging of the negative by secondary radiation from the under side of the metal, it seems that metal screens may play an increasingly important part as tube power is increased and greater metal penetration obtained. Possibly the combination of screens, described above, with increase in tube power to offset the lower intensifying factor will be found most advantageous.

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[1] Suggested by Ancel St. John.

FLUOROSCOPIC EXAMINATION

With present available tubes, X-ray visual examination for structural defects may be made where the thickness of section does not exceed about $1\frac{1}{2}$ in. of steel, and where the contour of the metal is favorable. For this work the radiation after passing through the metal is caught on a screen that gives a visible fluorescence under the influence of X-rays. Cavities or other defects stand out as brighter spots on the apple-green back-ground of the fluorescing screen. The method is not so sensitive as the radiographic method, cannot be used for as thick sections, does not give a permanent record and is applicable only to metal pieces of relatively simple contours. The method is also open to the objection that it is more difficult to protect the operator from the injurious effects of the rays. There is an advantage in the method in that it is more rapid than radiography and consequently less expensive.

TENTATIVE RECOMMENDED PRACTICE
FOR THE
CARE OF THE EYES WHEN USING A METALLOGRAPHIC MICROSCOPE[1]

Serial Designation: E 2 - 26 T

This is a **Tentative Standard** only, published for the purpose of eliciting criticism and suggestions. It is not a Standard of the Society and is subject to annual revision.

ISSUED, 1926.

All optical instruments of reputable make are so designed and optically corrected that there should be no discomfort to the user, if the eye is normal or corrected with proper spectacles and proper illumination is used, not forgetting that some eyes will bear brighter illumination than others.

In the microscopical examination of metals it is customary to use illuminants of high intensity to secure adequate illumination in photography. With the ordinary microscope or other optical instruments an illumination of 3 to 5 foot candles at the eyepiece is generally sufficient, and it should be in the examination of metals.

The carbon arc is a very bright light source and while desirable for photography, in order that the time of exposure of the photographic plate may be reduced as much as possible, is, nevertheless, dangerous for visual observation if not properly controlled. If a reduction of the illumination is made by means of diaphragms, it results in a reduction of the effective aperture of the objective and therefore the resolving power, that is, the ability of the objective to separate two closely situated points in the object. The back lens of the objective, when seen with the eyepiece removed, should be filled with light if full resolving power is desired.

Filters, placed between the light source and the vertical illuminator, as well as the colored glass cap fitting over the eyepiece, reduce the illumination and will generally be found sufficient for lamps such as the ribbon filament. If, however, an arc lamp is used, these filters will not be found to be sufficient to reduce the illumination for continuous observation, and if the outfit is so used a harmful blinding effect will be experienced. A remedy for this is by the use of filters of neutral smoke glass placed between the light source and the vertical illuminator.

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[1] This Tentative Recommended Practice was prepared by Mr. W. L. Patterson and, when adopted, is to be added as an appendix to the Recommended Practice for Photography as Applied to Metallography, appearing in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys (Serial Designation: E 2 - 24), 1924 Book of A.S.T.M. Standards.

Criticisms of this Tentative Recommended Practice are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, 967 Harrison Ave., Niagara Falls, N. Y.

Several degrees of density are advisable as specimens vary and observers vary in light sensitiveness. The darker filters will probably require the protection of a water cell as they absorb considerable heat and may break if unprotected.

For visual observation the illumination should be reduced to the lowest intensity that permits satisfactory results. Details appear to better advantage when glare is eliminated. If much visual work is to be done it would be advisable to have two interchangeable sources such as a ribbon filament for visual work and an arc lamp for photography.

It is the custom for trained observers with the microscope to keep both eyes open at all times. If one eye is closed a muscular strain is placed upon the eye in use. If one finds it difficult to keep both eyes open, an eyeshade may be placed before the unused eye. Such a shade may be made of cardboard, or a shade of hard rubber can be purchased for a nominal sum. Several metallurgists are using binocular eyepieces which permit the use of both eyes.

Observers who wear glasses, often remove them when using the microscope. If the defect in the eyes is limited to near or far sightedness, the deficiency may be corrected by focussing the microscope. If, however, the observer has astigmatism, a defect in which one meridian of the eye focuses at a different distance from another meridian, correction cannot be made by adjustment of the instrument. If the cylindrical power of ones spectacle lenses is one diopter or less, very little trouble will be experienced if the spectacles are not worn. Where greater cylindrical power is necessary, the spectacles should be worn or some other correction applied.

If it is found inconvenient to wear spectacles, owing to the difficulty in placing the eye at the eyepoint of the eyepiece, a cap containing a lens corresponding to the observers prescription can be placed over the eyepiece. The axis of the cylinder should be plainly marked upon the cap and care used to place this axis in position upon the microscope as given in the oculist's prescription.

In conclusion three cautions might be noted.

1. An illumination brighter than is necessary to make observations should not be used.
2. The unused eye should not be closed.
3. Spectacles should not be removed unless other means are provided for correcting the eye.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS

A. FERROUS METALS

STANDARD SPECIFICATIONS FOR CARBON-STEEL RAILS

(SERIAL DESIGNATION: A 1 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Open-Hearth Carbon-Steel Rails (A 1 – 26 T)"[2] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR THE MANUFACTURE OF OPEN-HEARTH STEEL GIRDER RAILS OF PLAIN, GROOVED AND GUARD TYPES

(SERIAL DESIGNATION: A 2 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (A 2 – 26 T)"[3] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR STEEL TRACK SPIKES

(SERIAL DESIGNATION: A 65 – 24)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Soft Steel Track Spikes (A 65 – 26 T)"[4] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR CARBON-STEEL BARS FOR RAILWAY SPRINGS

(SERIAL DESIGNATION: A 14 – 16)[1]

Section 6.—Change from its present form: namely,

"The permissible variations in the width and thickness of the bars shall be agreed upon by the manufacturer and the purchaser."

to read as follows:

"*Permissible Variations.*—The permissible variations in width and thickness of the bars shall be:

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

[2] See p. 621.

[3] See p. 626.

[4] See p. 631.

FLATS

	Variations in Width, In.		Variations in Thickness, In.			
			Up to ⅜ in., Inclusive		Over ⅜ to ⅝ in., Inclusive	
	Over	Under	Over	Under	Over	Under
1 to 2 in., incl.	0.030	0.015	0.015	0.005	0.015	0.010
Over 2 to 4 in., incl.	0.047	0.015	0.015	0.005	0.015	0.010
Over 4 to 6 in., incl.	0.062	0.032	0.015	0.005	0.015	0.010

ROUNDS AND SQUARES

	Variations in Diameter or Thickness, In.	
	Over	Under
Up to ½ in., incl.	0.007	0.007
Over ½ to 1 in., incl.	0.010	0.010
Over 1 to 2 in., incl.	0.016	0.016

STANDARD SPECIFICATIONS FOR CARBON-STEEL BARS FOR RAILWAY SPRINGS WITH SPECIAL SILICON REQUIREMENTS

(SERIAL DESIGNATION: A 68 – 18)[1]

Section 6.—Make the same change as in Section 6 of Specifications A 14 – 16 above.

STANDARD SPECIFICATIONS FOR CARBON-STEEL BARS FOR VEHICLE AND AUTOMOBILE SPRINGS

(SERIAL DESIGNATION: A 58 – 16)[1]

Title.—Change to read as follows:

"Carbon Steel Bars for Vehicle and General Purpose Springs."

Section 1.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"These specifications cover two grades of carbon-steel bars to be used for the manufacture of vehicle and [automobile] *general purpose* springs, determined by the carbon ranges specified in Section 3. The choice of the grade of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and services for which it is intended. [The purpose for which these grades are frequently used are as follows:

Grade A, for vehicle springs;
Grade B, for automobile springs.]

STANDARD SPECIFICATIONS FOR SILICO-MANGANESE-STEEL BARS FOR AUTOMOBILE AND RAILWAY SPRINGS

(SERIAL DESIGNATION: A 59 – 16)[1]

Title.—Change to read as follows:

"Silico-Manganese-Steel Bars for Railway Springs."

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Section 1.—Change to read as follows by the omission of the words in brackets:

"These specifications cover [two types of] silico-manganese-steel bars to be used for the manufacture of [automobile and] railway springs, [determined by the chemical composition specified in Section 3. The choice of the type of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended.]"

Section 3.—Change from its present form: namely,

"The steel shall conform to the following requirements as to chemical composition:

ELEMENTS CONSIDERED		TYPE A	TYPE B
Carbon, per cent		0.45 – 0.55	0.55 – 0.65
Manganese, per cent		0.60 – 0.80	0.50 – 0.70
Phosphorus, max., per cent	Acid	0.05	0.05
	Basic	0.045	0.045
Sulfur, max., per cent		0.045	0.045
Silicon, per cent		1.80 – 2.10	1.50 – 1.80"

to read as follows:

"The steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.55 – 0.65
Manganese, per cent	0.60 – 0.90
Silicon, per cent	1.80 – 2.20
Phosphorus, per cent	not over 0.045
Sulfur, per cent	not over 0.045"

Section 6.—Make the same change as in Section 6 of Specifications A 14 – 16 above.

STANDARD SPECIFICATIONS FOR CHROME-VANADIUM-STEEL BARS FOR AUTOMOBILE AND RAILWAY SPRINGS

(SERIAL DESIGNATION: A 60 – 16)[1]

Title.—Change to read as follows:

"Chrome-Vanadium-Steel Bars for Railway Springs."

Section 1.—Change to read as follows by the omission of the words in brackets:

"These specifications cover [two grades of] chrome-vanadium-steel bars to be used for the manufacture of [automobile and] railway springs, [determined by the chemical composition specified in Section 3. The choice of the grade of bar to be used for the manufacture of any spring will depend on the design of the spring and the stresses and service for which it is intended.]"

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

Section 3.—Change from its present form: namely,

"The steel shall conform to the following requirements as to chemical composition:

ELEMENTS CONSIDERED		GRADE A	GRADE B
Carbon, per cent		0.45 – 0.55	0.55 – 0.65
Manganese, per cent		0.50 – 0.80	0.60 – 0.90
Phosphorus, max., per cent	Acid	0.05	0.05
	Basic	0.04	0.04
Sulfur, max., per cent		0.05	0.05
Chromium, per cent		0.80 – 1.10	0.80 – 1.10
Vanadium, min., per cent		0.15	0.15"

to read as follows:

"The steel shall conform to the following requirements as to chemical composition:

Carbon, per cent	0.50 – 0.60
Manganese, per cent	0.60 – 0.90
Chromium, per cent	0.90 – 1.10
Phosphorus, per cent	not over 0.045
Sulfur, per cent	not over 0.045
Vanadium, per cent	not under 0.15"

Section 6.—Make the same change as in Section 6 of Specifications A 14 – 16 above.

STANDARD SPECIFICATIONS FOR ELLIPTICAL STEEL SPRINGS FOR AUTOMOBILES

(SERIAL DESIGNATION: A 69 – 18)[1]

It is recommended that these specifications be withdrawn from the Book of Standards.

STANDARD SPECIFICATIONS FOR CARBON-STEEL AND ALLOY-STEEL FORGINGS

(SERIAL DESIGNATION: A 18 – 21)[1]

STANDARD SPECIFICATIONS FOR QUENCHED-AND-TEMPERED CARBON-STEEL AXLES, SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS

(SERIAL DESIGNATION: A 19 – 21)[1]

STANDARD SPECIFICATIONS FOR CARBON-STEEL FORGINGS FOR LOCOMOTIVES

(SERIAL DESIGNATION: A 20 – 21)[1]

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

STANDARD SPECIFICATIONS FOR QUENCHED-AND-TEMPERED ALLOY-STEEL AXLES, SHAFTS AND OTHER FORGINGS FOR LOCOMOTIVES AND CARS

(SERIAL DESIGNATION: A 63 – 21)[1]

In Specifications A 18 – 21 change Section 4, and in Specifications A 20 – 21 change Section 5 from their present form: namely,

"The manufacturer and the purchaser shall agree upon forgings on which a prolongation for test purposes shall be provided."

and in Specifications A 19 – 21 and A 63 – 21 change Section 4 from its present form: namely,

"For test purposes, a prolongation shall be left on each forging, unless otherwise specified by the purchaser."

to read as follows:

"Unless otherwise specified, for test purposes at least 20 per cent of the forgings shall be provided with prolongations or, at the manufacturer's option, a forging may be selected."

In Specifications A 18 – 21 and A 20 – 21 change Section 17 (*a*), and in Specifications A 19 – 21 and A 63 – 21 change Section 19 (*a*) from their present form: namely,

"The inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment."

to read as follows:

"The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the forgings ordered. The manufacturer shall afford the inspector, without charge, all reasonable facilities to satisfy him that the forgings are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works."

STANDARD SPECIFICATIONS FOR CARBON-STEEL CAR AND TENDER AXLES

(SERIAL DESIGNATION: A 21 – 18)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Carbon-Steel Car and Tender Axles (A 21 – 25 T)"[2] is intended to replace the present standard specifications.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 509 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 57.

STANDARD SPECIFICATIONS FOR WELDED AND SEAMLESS STEEL PIPE

(SERIAL DESIGNATION: A 53 – 24)[1]

Section 1.—Change from its present form: namely,

"These specifications cover 'standard,' 'extra strong' and 'double extra strong' welded and seamless steel pipe. Pipe ordered under these specifications is intended for bending, flanging and other special purposes."

to read as follows:

"*Scope.*—These specifications cover 'standard weight,' 'extra strong,' and 'double extra strong' welded and seamless steel pipe. Pipe ordered under these specifications is intended for coiling, bending, flanging and other special purposes. Butt-welded pipe is not intended for flanging. The purposes for which the pipe is intended should be stated in the order. Where seamless pipe is ordered for coiling, bending or welding, the low-carbon grade should be specified."

Section 2.—Add a new Paragraph (*c*) to read as follows:

"(*c*) Lap-welded pipe ordered for flanging shall be given a double-welding operation."

Section 3.—Change the present Section 3 to Section 3 (*a*), and add a new Paragraph (*b*) reading as follows:

"(*b*) *Check Analyses.*—Analyses may be made by the purchaser from each lot of 500 lengths or less of finished pipe. The phosphorus content thus determined shall not exceed that specified in Paragraph (*a*) by more than 25 per cent."

Section 6. (*a*).—Change from its present form: namely,

"For lap-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks."

to read as follows:

"(*a*) For lap-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks. Where welded pipe is ordered for flanging, the weld in this test shall be located 90 deg. from the line of direction of the applied force."

Insert new Paragraphs (*c*) and (*d*) to read as follows, relettering the subsequent paragraph accordingly:

"(*c*) For low-carbon seamless pipe 2 in. in diameter, a section of pipe not less than 2½ in. long shall be flattened between parallel plates until the distance between the plates is one-third the outside diameter of the pipe, without developing cracks. In no case need the distance between plates be less than five times the thickness of the pipe."

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

"(*d*) For medium-carbon seamless pipe over 2 in. in diameter, a section of pipe not less than 2½ in. long shall be flattened between parallel plates until the distance between the plates is one-half the outside diameter of the pipe, without developing cracks. In no case need the distance between plates be less than seven times the thickness of the pipe."

Section 7.—Change from its present form: namely,

"For pipe 2 in. or under in diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld. This test will not be required on double extra strong pipe over 1¼ in. in diameter."

to read as follows:

"For pipe 2 in. or under in diameter, a sufficient length of pipe shall stand being bent cold through 90 deg. around a cylindrical mandrel the diameter of which is 12 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld. When ordered for close coiling, the pipe shall stand being bent cold through 180 deg. around a mandrel the diameter of which is eight times the diameter of the pipe, without failure. The bend test will not be required on double extra strong pipe over 1¼ in. in diameter."

Section 9.—Change from its present form: namely,

"One of each of the tests specified in Sections 4, 6 and 7, may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test."

to read as follows:

"One of each of the tests specified in Sections 4, 6 and 7 may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test. In the case of welded pipe ordered for flanging, the crop ends cut from each length shall withstand the flattening test specified in Section 6 (*a*)."

Section 10.—Change from its present form: namely,

"If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 and 7, retests of two additional pipes shall be made, each of which shall conform to the requirements specified."

to read as follows:

"If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 and 7, retests of two additional pipes shall be made, each of which shall conform to the requirements specified. In the case of flattening tests on the crop ends of each length of welded pipe, if any section fails, other pieces from the length may be cut until satisfactory tests are obtained, otherwise the length shall be rejected."

STANDARD SPECIFICATIONS FOR BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE

(SERIAL DESIGNATION: A 70 – 24)[1]

Section 8.—Change the present Section 8 to Section 8 (*a*), and add a new Paragraph (*b*) to read as follows:

"(*b*) *Bend Test for Universal Edge Rolled Plates When Permitted for Double-Butt-Strap Construction.*—The bend test specimen shall stand being bent cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to 1½ times the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to three times the thickness of the specimen."

STANDARD SPECIFICATIONS FOR COLD-FINISHED BESSEMER STEEL AUTOMATIC SCREW STOCK

(SERIAL DESIGNATION: A 32 – 24)[1]

Revisions in the form of two separate tentative specifications entitled "Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 26 T)"[2] and "Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 26 T)"[3] are intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR COLD-FINISHED OPEN-HEARTH STEEL AUTOMATIC SCREW STOCK

(SERIAL DESIGNATION: A 54 – 24)[1]

Revisions in the form of two separate tentative specifications entitled "Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 26 T)"[2] and "Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 26 T)"[3] are intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR COMMERCIAL BAR STEELS

(SERIAL DESIGNATION: A 80 – 24)[1]

Revisions in the form of two separate tentative specifications entitled "Specifications for Commercial Quality Hot-Rolled Bar Steels (A 107 – 26 T)"[2] and "Specifications for Commercial Cold-Finished Bar Steels and Cold-Finished Shafting (A 108 – 26 T)"[3] are intended to replace the present standard specifications.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co, Reading, Pa.

[2] See p. 652.

[3] See p. 656.

STANDARD SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL AND LAP-WELDED IRON BOILER TUBES

(SERIAL DESIGNATION: A 83 - 24)[1]

Section 16.—Insert a new Paragraph (*e*) to read as follows, relettering the subsequent paragraph accordingly:

"(*e*) The gaging tolerances in Paragraphs (*b*), (*c*) and (*d*) apply only to tubes as rolled or drawn and before swaging and expanding."

STANDARD SPECIFICATIONS FOR WELDED WROUGHT-IRON PIPE

(SERIAL DESIGNATION: A 72 - 24)[2]

Section 1.—Change from its present form: namely,

"These specifications cover 'standard,' 'extra strong' and 'double extra strong' welded wrought-iron pipe."

to read as follows:

"These specifications cover 'standard weight,' 'extra strong' and 'double extra strong' welded wrought-iron pipe. Pipe ordered to these specifications is intended for coiling, bending, flanging, and other special purposes. Butt-welded pipe is not intended for flanging."

Section 3 (b).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"(*b*) All pipe [3 in. or under] *under 2 in.* in nominal diameter may be butt-welded, unless otherwise specified. All pipe [over 3 in.] *2 in. or over* in nominal diameter shall be lap welded."

Section 9.—Add a new Section 9 to follow the present Section 8 to read as follows, renumbering the subsequent sections accordingly:

"In case of doubt as to the presence of steel, the purchaser may, at his own expense, make micrographic examination and chemical analysis to assist in determining whether the material meets the requirements of Section 3 (*a*)."

STANDARD SPECIFICATIONS FOR STAYBOLT, ENGINE-BOLT AND EXTRA-REFINED WROUGHT-IRON BARS

(SERIAL DESIGNETION: A 84 - 24)[2]

Section 2.—Change to read as follows by the addition of the italicized words:

"*Grade A.*—The iron shall be rolled from a bloom, slab pile or box pile made wholly from reworked all-pig puddled iron or reworked knobbled charcoal iron. *The original puddled or knobbled bar shall be twice piled and rerolled. All bars shall be the full length of the piles.* The puddle mixture and the component parts of the bloom, slab pile or box pile shall be free from any admixture of iron scrap or steel."

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. H. Woodroffe, Secretary of Committee A-1 on Steel, Reading Iron Co., Reading, Pa.

[2] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. H. J. Force, Chairman of Committee A-2 on Wrought Iron, Delaware, Lackawanna and Western Railroad Co., Scranton, Pa.

Section 7.—Add two new Paragraphs (*b*) and (*c*) to read as follows, re-lettering the present Paragraph (*b*) to Paragraph (*d*):

"(*b*) *Grade A.*—For bars $1\frac{1}{4}$ sq. in. in sectional area, the following deductions from the minimum requirements specified in Section 6 (*a*) shall be made for each square inch of nominal section above $1\frac{1}{4}$ sq. in.:

Tensile strength, 250 lb., but not under 46,000 lb.

Reduction of area, 3 per cent, but not under 40 per cent.

"(*c*) *Grade A.*—For flats of all sizes, the minimum reduction of area shall be 40 per cent."

Section 12.—Change the first paragraph relating to the requirements for permissible variations for the sizes of bars of Grade A material from its present form: namely,

"*Grade A.*—The bars shall be truly round within 0.01 in., and shall not vary more than 0.01 in. above nor more than 0.005 in. below the specified size."

to read as follows:

"*Grade A.*—The bars shall be truly round within 0.01 in. and shall be not less than 0.005 in. over, nor more than 0.020 in. over the specified diameter."

STANDARD SPECIFICATIONS FOR MERCHANT BAR IRON

(SERIAL DESIGNATION: A 85 - 24)[1]

Title.—Change from its present form to read as follows:

"Standard Specifications for *Common Iron Bars.*"

STANDARD SPECIFICATIONS FOR MALLEABLE CASTINGS

(SERIAL DESIGNATION: A 47 - 24)[2]

Section 3.—Add to the table of requirements a requirement on minimum yield point, as follows:

"Yield point, lb. per sq. in., minimum........ 30 000"

Add a new paragraph (*b*) to read as follows:

"(*b*) The yield point shall be determined by the drop of the beam of the testing machine."

STANDARD DEFINITIONS OF TERMS RELATING TO WROUGHT-IRON SPECIFICATIONS

(SERIAL DESIGNATION: A 81 - 21)[1]

Omit the definition for merchant bar iron.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. H. J. Force, Chairman of Committee A-2 on Wrought Iron, Delaware, Lackawanna and Western Railroad Co., Scranton, Pa.

[2] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Enrique Touceda, Secretary of Committee A-7 on Malleable Castings, 943 Broadway, Albany, N. Y.

STANDARD METHODS OF TEST FOR MAGNETIC PROPERTIES OF IRON AND STEEL

(SERIAL DESIGNATION: A 34 – 24)[1]

A revision in the form of separate methods of test entitled "Methods of Test for Magnetic Properties of Iron and Steel (A 34 – 26 T)"[2] is intended to replace the present standard methods.

RECOMMENDED PRACTICE FOR HEAT TREATMENT OF CASE-HARDENED CARBON-STEEL OBJECTS

(SERIAL DESIGNATION: A 37 – 14)[3]

A revision in the form of a separate tentative recommended practice entitled "Recommended Practice for Carburizing and Heat Treatment of Carburized Objects (A 37 – 25 T)"[4] is intended to replace the present recommended practice.

B. NON-FERROUS METALS

STANDARD SPECIFICATIONS FOR LAKE COPPER WIRE BARS, CAKES, SLABS, BILLETS, INGOTS, AND INGOT BARS

(SERIAL DESIGNATION: B 4 – 13)[5]

Section 4 (a).—Change the first sentence in the second paragraph to read as follows by the addition of the italicized figures and the omission of those in brackets:

> "Low Resistance Lake wire bars shall have a resistivity not to exceed [0.15535] *0.15436* international ohms per meter-gram at 20° C. (annealed)."

Section 5 (a).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

> "Low Resistance Lake copper shall have a purity of at least [99.880] *99.900* per cent as determined by electrolytic assay, silver being counted as copper."

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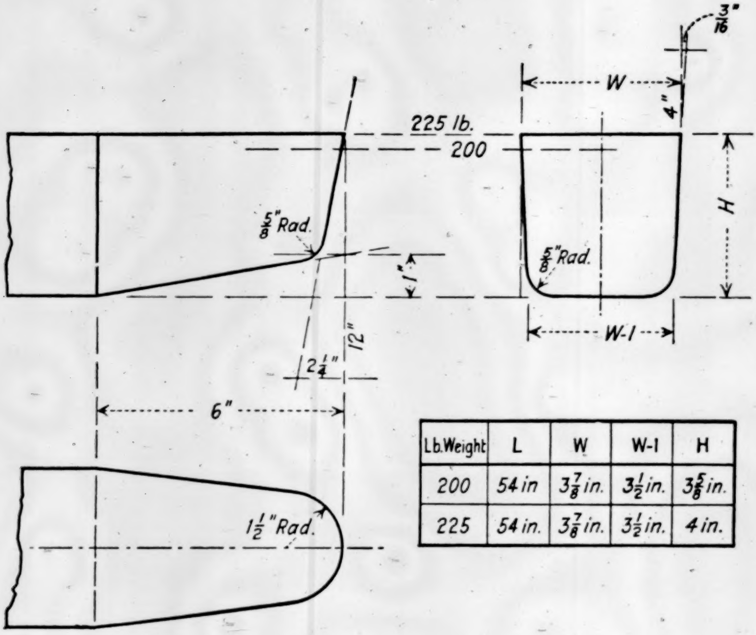
[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Sanford, Secretary of Committee A-6 on Magnetic Properties, U. S. Bureau of Standards, Washington, D. C.

[2] See p. 675.

[3] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. H. Hall, Secretary of Committee A-4 on Heat Treatment of Iron and Steel, Taylor-Wharton Iron and Steel Co., High Bridge, N. J.

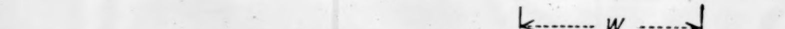
[4] *Proceedings*, Am. Soc. Testing Mats., Vol. 25, Part I, p. 568 (1925); also 1926 Book of A.S.T.M. Tentative Standards, p. 156.

[5] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.


225 lb.
200
$\frac{5}{8}$" Rad.
1"
12"
$2\frac{1}{4}$"
6"
$1\frac{1}{2}$" Rad.
W
4"
$\frac{3}{16}$"
H
$\frac{5}{8}$" Rad.
W-1

Lb. Weight	L	W	W-1	H
200	54 in	$3\frac{7}{8}$ in.	$3\frac{1}{2}$ in.	$3\frac{5}{8}$ in.
225	54 in.	$3\frac{7}{8}$ in.	$3\frac{1}{2}$ in.	4 in.

FIG. 1.


300 lb.
275
250
1" Rad.
1"
12"
$2\frac{1}{4}$"
6"
$1\frac{1}{2}$" Rad.
W
$\frac{3}{16}$"
4"
H
$\frac{5}{8}$" Rad.
W_1

Lb. Weight	L	W	W_1	H
250	54 in.	$4\frac{3}{8}$ in.	4 in.	4 in.
275	54 in.	$4\frac{3}{8}$ in.	4 in.	$4\frac{3}{8}$ in.
300	54 in.	$4\frac{3}{8}$ in.	4 in.	$4\frac{3}{4}$ in.

FIG. 2.

Section 5 (b).—Change the first sentence to read as follows by the addition of the italicized figures and the omission of those in brackets:

"High Resistance Lake copper shall have a purity of at least [99.880] *99.900* per cent, copper, silver, and arsenic being counted together."

Section 7.—Add a new Section 7 to read as follows, renumbering the subsequent sections accordingly:

"7. *Standard Sizes and Shapes for 200 to 300-lb. Wire Bars.*—(*a*) One mold shall be used for casting 200 to 230-lb. wire bars, the bottom width of this bar to be 3½ in., the listed weights being 200 and 225 lb. (See Fig. 1.)

"(*b*) One mold shall be used for casting 240 to 300-lb. wire bars, the bottom width of this bar to be 4 in., the listed weights being 250, 275 and 300 lb. (See Fig. 2.)

"(*c*) The length dimension of all bars shall be 54 in. The side draft or taper shall be ⅜ in. in 4 in. (3/16 in. in 4 in. on each side of the bar). The radius of the corners at the bottom of the bars shall be ⅝ in. The end taper at the bottom shall be 6 in. long overall and approximately 2 in. per ft.

"The end taper of the side shall be approximately 2¼ in. per ft. and the end of the bar shall be approximately 3⅜ in. deep at the point."

Section 9.—Change the second paragraph from its present form: namely,

"In a question of metal contents each party shall select a sample of two pieces. These shall be drilled in the presence of both parties, several holes approximately ½ in. in diameter being drilled completely through each piece; scale from set shall be rejected. No lubricant shall be used and drilling shall not be forced sufficiently to cause oxidation of chips. The resulting samples shall be cut up, mixed, and separated into three parts, each of which shall be placed in a sealed package, one for each party and one for the umpire if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact, and whose determination shall be final."

to read as follows:

"In a question of metal contents, each party shall select a sample of three pieces from the consignment or lot to be investigated. These shall be sampled in the presence of both parties by drilling five holes, approximately ½ in. in diameter, at points equally spaced between the ends of the pieces. With bars, billets, ingots, and ingot bars, these holes should be along a middle line and with slabs and cakes on a diagonal line projected between opposite corners. The drilling shall be from top to bottom and completely through each piece. Scale from set and any surface dirt shall be rejected. No lubricant shall be used and drilling shall not be forced sufficiently to cause oxidation of the chips. In the case of sections having a depth greater than 5 in., drillings may be made from both top and bottom for a depth of not less than 2 in. in each direction instead of completely through, but the drilling shall be otherwise conducted as before described.

"The resulting sample shall be cut up, mixed and separated into three equal portions, each of which shall be placed in a sealed package, one for each party and the third for the umpire, if necessary.

"Each party shall make an analysis by the Standard Method of Battery Assay of Copper (B 34 - 20) of the American Society for Testing Materials and if the results do not establish or dismiss the claim to the satisfaction of both parties concerned, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact and whose determination shall be final."

STANDARD SPECIFICATIONS FOR ELECTROLYTIC COPPER WIRE BARS, CAKES, SLABS, BILLETS, INGOTS, AND INGOT BARS

(SERIAL DESIGNATION: B 5 - 13)[1]

Section 3 (a).—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"*Metal Content.*—The copper in all shapes shall have a purity of at least [99.880] *99.900* per cent, as determined by [electrolytic assay] *the A.S.T.M. Standard Method of Battery Assay of Copper (B 34 - 20)*, silver being counted as copper."

Section 3 (b).—Change to read as follows by the addition of the italicized figures and the omission of those in brackets:

"*Resistivity.*—All wire bars shall have a resistivity not to exceed [0.15535] *0.15436* international ohms per meter-gram at 20° C. (annealed); all ingots and ingot bars shall have a resistivity not to exceed 0.15694 international ohms per meter-gram at 20° C. (annealed)."

Section 6.—Add a new Section 6 to agree with the new Section 7 added to Specifications B 4 - 13 above, renumbering the subsequent sections accordingly.

Section 7.—Change the second paragraph from its present form: namely,

"In a question of metal contents each party shall select a sample of two pieces. These shall be drilled in the presence of both parties, several holes approximately ½ in. in diameter being drilled completely through each piece; scale from set shall be rejected. No lubricant shall be used and drilling shall not be forced sufficiently to cause oxidation of chips. The resulting samples shall be cut up, mixed, and separated into three parts, each of which shall be placed in a sealed package, one for each party and one for the umpire if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact, and whose determination shall be final."

to read as follows:

"In a question of metal contents, each party shall select a sample of three pieces from the consignment or lot to be investigated. These shall be sampled in the presence of both parties by drilling five holes approximately ½ in. in diameter, at points equally spaced between the ends of the pieces. With bars, billets, ingots, and ingot bars, these holes should be along a middle line and with slabs and cakes on a diagonal line projected between opposite corners. The drilling shall be from top to bottom and completely through each piece. Scale from set and any surface dirt shall be rejected. No lubricant shall be used and drilling shall not be forced sufficiently to cause oxidation of the chips. In the case of sections having a depth greater than 5 in., drillings may be made from both top and bottom for a depth of not less than 2 in. in each direction instead of completely through, but the drilling shall be otherwise conducted as before described.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

"The resulting sample shall be cut up, mixed and separated into three equal portions, each of which shall be placed in a sealed package, one for each party and the third for the umpire, if necessary.

"Each party shall make an analysis and if the results do not establish or dismiss the claim to the satisfaction of both parties concerned, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of fact and whose determination shall be final."

STANDARD SPECIFICATIONS FOR HARD-DRAWN COPPER WIRE

(SERIAL DESIGNATION: B 1 – 23)[1]

Section 6.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "For the purpose of calculating weights, cross-sections, etc., the [specific gravity] *density* of copper shall be taken as 8.89 *g. per cu. cm.* at 20° C. (*68 F.*) (Note 4)."

Change the explanatory note applying to this section to read as follows:

> "Unit weights were formerly defined in these specifications on the basis of specific gravity of copper. This has been changed to basis of density to agree literally with the definition of the Annealed Copper Standard adopted by the International Electrotechnical Commission."

STANDARD SPECIFICATIONS FOR MEDIUM HARD-DRAWN COPPER WIRE

(SERIAL DESIGNATION: B 2 – 15)[1]

These specifications have been rewritten as to form so as to bring them in line with the Standard Specifications for Hard-Drawn Copper Wire (B 1 – 23), which specifications had been revised as to form in accordance with the Regulations Governing the Form but not the Substance of Standards prior to the publication of the 1924 Book of A.S.T.M. Standards.

Section 5 (Section 6 of the redrafted specifications).—Make the same change as in Section 6 of Specifications B 1 – 23 above.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

Change the explanatory note applying to this section to agree with the explanatory note to Section 6 of Specifications B 1 – 23 given above.

STANDARD SPECIFICATIONS FOR SOFT OR ANNEALED COPPER WIRE

(SERIAL DESIGNATION: B 3 – 15)[1]

These specifications have been rewritten as to form so as to bring them in line with the Standard Specifications for Hard-Drawn Copper Wire (B 1 – 23).

Section 5 (Section 6 of the redrafted specifications).—Make the same change as in Section 6 of Specifications B 1 – 23 above.

Change the explanatory note applying to this section to agree with the explanatory note to Section 6 of Specifications B 1 – 23 given above.

STANDARD SPECIFICATIONS FOR BARE CONCENTRIC-LAY COPPER CABLE: HARD, MEDIUM-HARD, OR SOFT

(SERIAL DESIGNATION: B 8 – 21)[1]

Section 6 (*first sentence*).—Make the same change as in Section 6 of Specifications B 1 – 23 above.

STANDARD SPECIFICATIONS FOR ROUND AND GROOVED HARD-DRAWN COPPER TROLLEY WIRE

(SERIAL DESIGNATION: B 47 – 25)[2]

Section 8.—Make the same change as in Section 6 of Specifications B 1 – 23 above.

Figure 1.—Change the figures for Actual Area of 300,000 cir. mils size of grooved wire from 0.2356 sq. in. to 0.2355 sq. in.

Change the figures for calculated weight of grooved wire from 4786, 3382, 2669 and 2201 lb. to 4792, 3389, 2674 and 2205 lb., respectively.

Section 11 (*a*).—Change the figures for Actual Area of 300,000 cir. mils size of grooved wire from 0.2356 sq. in. to 0.2355 sq. in.

Change the figures for calculated weight of grooved wire from 4786, 3382, 2669 and 2201 lb. to 4792, 3389, 2674 and 2205 lb., respectively.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] A.S.T.M. Standards Adopted in 1925. Criticisms of this revision are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

STANDARD SPECIFICATIONS FOR HIGH-STRENGTH BRONZE TROLLEY WIRE, ROUND AND GROOVED: 40 AND 65 PER CENT CONDUCTIVITY

(SERIAL DESIGNATION: B 9 - 16)[1]

A revision in the form of separate tentative specifications entitled "Specifications for Bronze Trolley Wire (B 9 - 26 T)"[2] is intended to replace the present standard specifications.

TABLE I.—PERMISSIBLE VARIATIONS IN THICKNESS OF HIGH SHEET BRASS, IN.

Thickness		Width, in.			
B. & S. Gage No.	Inch	Up to 6 in., inclusive	Over 6 to 9 in., inclusive	Over 9 to 14 in., inclusive	Over 14 to 20 in., inclusive
0000	0.460	0.0043	0.0045	0.0047	0.0049
000	0.4096	0.0042	0.0044	0.0046	0.0048
00	0.3648	0.0041	0.0043	0.0045	0.0047
0	0.3249	0.0040	0.0042	0.0044	0.0046
1	0.2893	0.0039	0.0041	0.0043	0.0045
2	0.2576	0.0038	0.0040	0.0042	0.0044
3	0.2294	0.0037	0.0039	0.0041	0.0043
4	0.2043	0.0036	0.0038	0.0010	0.0042
5	0.1819	0.0035	0.0037	0.0039	0.0041
6	0.1620	0.0034	0.0036	0.0038	0.0010
7	0.1443	0.0033	0.0035	0.0037	0.0039
8	0.1285	0.0032	0.0034	0.0036	0.0038
9	0.1144	0.0031	0.0033	0.0035	0.0037
10	0.1019	0.0030	0.0032	0.0034	0.0036
11	0.0907	0.0029	0.0031	0.0033	0.0035
12	0.0808	0.0028	0.0030	0.0032	0.0034
13	0.0719	0.0027	0.0029	0.0031	0.0033
14	0.0640	0.0026	0.0028	0.0030	0.0032
15	0.0570	0.0025	0.0027	0.0029	0.0031
16	0.0508	0.0024	0.0026	0.0028	0.0030
17	0.0452	0.0023	0.0025	0.0027	0.0029
18	0.0403	0.0022	0.0024	0.0026	0.0028
19	0.0359	0.0021	0.0023	0.0025	0.0026
20	0.0320	0.0020	0.0021	0.0023	0.0024
21	0.0284	0.0019	0.0020	0.0021	0.0022
22	0.0253	0.0018	0.0019	0.0020	0.0021
23	0.0225	0.0017	0.0018	0.0019	0.0020
24	0.0201	0.0016	0.0017	0.0018	0.0019
25	0.0179	0.0015	0.0016	0.0017	0.0018
26	0.0159	0.0014	0.0015	0.0016	0.0017
27	0.0142	0.0013	0.0014	0.0015	0.0016
28	0.0126	0.0012	0.0013	0.0014	0.0015
29	0.0112	0.0011	0.0012	0.0013	0.0014
30	0.0100	0.0011	0.0012	0.0013	0.0014
31	0.0089	0.0010	0.0011	0.0012	0.0013
32	0.0079	0.0010	0.0011	0.0012	0.0013
33	0.0070	0.0009	0.0010	0.0011	0.0012
34	0.0063	0.0009	0.0010	0.0011	0.0012
35	0.0056	0.0008	0.0009	0.0010	0.0011
36	0.0050	0.0008	0.0009	0.0010	0.0011

STANDARD SPECIFICATIONS FOR LIGHT ALUMINUM CASTING ALLOYS

(SERIAL DESIGNATION: B 26 - 21)[3]

A revision in the form of separate tentative specifications entitled "Specifications for Aluminum Base Alloy Sand Castings (B 26-26 T)"[4] is intended to replace the present standard specifications.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

[2] See p. 682.

[3] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

[4] See p. 693.

STANDARD SPECIFICATIONS FOR SEAMLESS ADMIRALTY CONDENSER TUBES AND FERRULE STOCK

(SERIAL DESIGNATION: B 44 – 24)[1]

Section 12.—Insert under Sub-Heading IV on Permissible Variations in Dimensions, a new Section 12 to read as follows, renumbering the subsequent sections accordingly:

"12. *Diameter.*—The outside diameter of the tubes shall not vary from that specified by more than the following amounts, as measured by 'go' and 'no go' ring gages:

NOMINAL DIAMETER, IN.	PERMISSIBLE VARIATION, IN.
Up to 0.500, inclusive	plus or minus 0.002
Over 0.500 to 0.740, inclusive	" " " 0.0025
Over 0.740 to 1.000, "	" " " 0.003
Over 1.000 to 1.250, "	" " " 0.0035
Over 1.250 to 1.500, "	" " " 0.004

STANDARD SPECIFICATIONS FOR HIGH SHEET BRASS

(SERIAL DESIGNATION: B 36 – 21)[1]

Table I.—Change Table I in Section 13, covering permissible variations in thickness, to agree with the accompanying Table I.

STANDARD SPECIFICATIONS FOR NAVAL BRASS RODS FOR STRUCTURAL PURPOSES

(SERIAL DESIGNATION: B 21 – 19)[1]

Section 6.—Add a paragraph to read as follows:

"(*b*) Yield point in tension shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in."

STANDARD METHODS OF CHEMICAL ANALYSIS OF BRASS INGOTS AND SAND CASTINGS

(SERIAL DESIGNATION: B 45 – 23)[1]

STANDARD METHODS OF CHEMICAL ANALYSIS OF BRONZE BEARING METAL

(SERIAL DESIGNATION: B 46 – 23)[1]

Add to both standards two methods for the determination of aluminum in small quantities, one method for accurate work and one method for control work, as given below:

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. P. D. Merica, Secretary of Committee B-2 on Non-Ferrous Metals and Alloys, International Nickel Co., 67 Wall St., New York City.

METHOD FOR THE DETERMINATION OF ALUMINUM IN SMALL QUANTITIES

A. GENERAL METHOD FOR ACCURATE WORK

SOLUTIONS REQUIRED

"Electrolytic Solution."—Mix 300 cc. of HNO_3 (sp. gr. 1.42), 1700 cc. of distilled water, and 500 cc. of H_2SO_4 (sp. gr. 1.84).

Acidified H_2S Water for Washing.—Dilute 10 cc. of HCl (sp. gr. 1.19) with 1000 cc. of distilled water and saturate with H_2S.

***Phenylhydrazine Solution** for Washing.*—Add saturated SO_2 water to a few cubic centimeters of phenylhydrazine until the crystallin sulfite first formed is redissolved, and then add phenylhydrazine, drop by drop, with vigorous agitation, until the odor of SO_2 is no longer perceptible; dilute 5 to 10 cc. of this solution with 100 cc. of hot water and allow to remain at the boiling point for a few minutes so as to get rid of the excess SO_2.

NH_4Cl Solution for Washing (2-per-cent).—Mix 30 cc. of HCl (sp. gr. 1.19) with 200 cc. of distilled water, add methyl red, neutralize with NH_4OH until the solution changes to a distinct yellow, and then dilute to 1000 cc. with water.

METHOD

Dissolve 1 g. of brass or bronze in 35 cc. of "electrolytic solution," dilute with 100 cc. of distilled water and remove copper by electrolysis. Evaporate the electrolyte to fumes of SO_3. (If much tin is present, boil the sulfuric acid solution vigorously for a few minutes.) Cool and dilute with 100 cc. of water. Filter off $PbSO_4$ and any tin which may be precipitated at this point, washing with hot water. Dilute the filtrate to at least 200 cc.

Pass H_2S into the filtrate for 30 minutes. This will precipitate any copper, lead, tin, arsenic, or antimony which may be present. Allow the sulfides to settle, and filter, washing with acidified H_2S water. Boil the filtrate to one-half volume to expel H_2S, add 3 cc. HNO_3 (sp. gr. 1.42) and boil for a few minutes to oxidize iron.

Precipitate iron and aluminum according to the following[1]: Add 10 cc. of HCl (sp. gr. 1.19) and just neutralize with NH_4OH, using methyl red as an indicator. Boil for two minutes and filter, washing with hot 2-per-cent NH_4Cl. Dissolve the precipitate from the paper with *boiling hot* HCl (1:1) and wash alternately with hot water and HCl (1:1) into the beaker in which the precipitation was made. Reprecipitate the iron and aluminum following the same procedure as before.

Dissolve the precipitate again with hot HCl (1:1), dilute to 100 cc. with water, make just ammoniacal, then only acid enough to hold iron in solution. Add sufficient saturated solution of ammonium bisulfite to reduce the iron (5 to 20 drops). Add a few drops of methyl orange, quickly bring to neutrality with NH_4OH, and then add 6 to 7 drops of HCl (1:1) in excess. Finally add from 1 to 3 cc. of phenylhydrazine and stir until the precipitate becomes flaky. The supernatant liquid should be plainly acid to litmus and the precipitate may be colored owing to organic matter. Filter and wash with phenylhydrazine wash solution. Ignite in a weighed platinum crucible, finishing with the blast for 5 minutes. Weigh as Al_2O_3. The weighing should be made rapidly and with the crucible covered as Al_2O_3 is somewhat hygroscopic.

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[1] Blum: U. S. Bureau of Standards *Scientific Paper, No. 286,* 1916; *Journal,* American Chemical Society, Vol. 38, 1282 (1916).

NOTES

1. For small amounts of aluminum, a 5-g. sample should be used. In this case dissolve in 60 cc. of "assay solution" of the following proportions:

7 volumes HNO_3 (sp. gr. 1.42);
10 volumes H_2SO_4 (sp. gr. 1.84);
25 volumes H_2O.

2. When phosphorus is present the final precipitate will be $Al_2O_3+P_2O_5$. In this case it is necessary to fuse the residue with Na_2CO_3, dissolve with hot water, acidify with HNO_3, and determine phosphorus according to the Alkalimetric Method of the Standard Methods of Chemical Analysis of Bronze Bearing Metal (Serial Designation: B 46)[1] The phosphorus is calculated to P_2O_5 and subtracted.

3. For accurate work the Al_2O_3 residue is treated with HF and H_2SO_4 for the removal of possible SiO_2.

4. Ammonium bisulfite solution may be prepared by saturating cold NH_4OH (1:1) with SO_2 until yellow.

5. This method is especially satisfactory for small amounts of aluminum in brass or bronze since no reagents are used which may contaminate the precipitate with aluminum, iron or silica. A precipitate with phenylhydrazine gives positive indication of the presence of aluminum.

B. RAPID METHOD FOR CONTROL WORK

SOLUTIONS REQUIRED

Sodium Hydroxide Solution (*2.5-per-cent*).—Dissolve 25 g. of NaOH (free from aluminum) in water and dilute to 1000 cc.

Sodium Sulfide Solution.—Dissolve 150 g. of NaOH (free from aluminum) in 1000 cc. of water, saturate 500 cc. of this solution with hydrogen sulfide, and mix with the remaining 500 cc. of solution.

Dilute Hydrochloric Acid (*1:3*).—Mix 200 cc. of HCl (sp. gr. 1.19) with 600 cc. of water.

Acidified Hydrogen Sulfide Water.—Dilute 10 cc. of HCl (sp. gr. 1.19) with 1000 cc. of water and saturate the solution with hydrogen sulfide.

Ammonium Chloride Solution (*2-per-cent*).—Mix 30 cc. of HCl (sp. gr. 1.19) with 200 cc. of water, add methyl red, neutralize with ammonia until the solution changes to a distinct yellow, and then dilute to 1000 cc. with water.

METHOD

Dissolve 2 g. of the sample in 20 cc. of HCl (sp. gr. 1.19) and 5 cc. of HNO_3 (sp. gr. 1.42). Boil the solution to expel chlorine and dilute with 50 cc. of water. Nearly neutralize the cold solution with sodium hydroxide solution (2.5-per-cent, or stronger if much free acid is present), and pour it slowly and with constant shaking into a 500-cc. volumetric flask containing 100 cc. of sodium sulfide solution. Dilute to the mark with sodium hydroxide solution

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[1] 1924 Book of A.S.T.M. Standards.

(2.5-per-cent) and mix thoroughly. Filter on a large, dry, No. 42 Whatman filter paper (or its equivalent) and keep the paper well filled with the solution lest iron be oxidized and dissolved. Reject the first 20 to 25 cc., and catch exactly 250 cc. which will represent 1 g. of sample. In routine analyses of material containing not more than 1 per cent of aluminum, the aliquot portion can be gathered in a 250-cc. graduate.

Transfer the aliquot portion to a 600-cc. beaker, neutralize the solution with dilute HCl (1:3), and finally add 25 cc. in excess. Digest at 40 to 60° C. for 1 hour, filter, and wash the paper and precipitate with acidified hydrogen sulfide water.

Boil the filtrate and washings to expel hydrogen sulfide, add a few drops of methyl red indicator, and then dilute ammonia (1:2) until the solution is just distinctly yellow. Boil for 1 to 2 minutes and filter at once through a small filter. Wash the beaker, paper, and precipitate two or three times with hot ammonium chloride solution (2-per-cent) and discard the filtrate. Dissolve the precipitate in 200 cc. of hot dilute HCl (1:3), wash the filter thoroughly with small portions of hot water, and reserve it for the second filtration. Dilute the filtrate to 50 cc., add methyl red, and precipitate with dilute ammonia (1:2) as before. Filter, wash with hot ammonium chloride solution (2-per-cent), ignite, and weigh.

The ignited residue is prone to carry silica and must be purified before weighing as follows: Add one or two drops of water, one drop of diluted H_2SO_4, and 1 to 5 cc. of HF. Evaporate to dryness, increase the heat slowly, and finally heat with a blast lamp or its equivalent. Weigh as Al_2O_3. The weight of Al_2O_3 corrected for the blank and multiplied by 52.94 gives the percentage of aluminum.

NOTES

The first aluminum hydroxide precipitate will carry down some sodium chloride and much of any silica that was dissolved in the sodium hydroxide solution; hence it is not safe to omit the second precipitation and the hydrofluoric acid treatment. There is no attack on the glassware during the short contact with the weak, cool, alkaline solution. It is, of course, preferable that the sodium hydroxide be free from aluminum. The most satisfactory test for it lies in running an analysis with non-ferrous alloys containing no aluminum. Direct test, by acidification followed by precipitation with ammonia, is sufficient if no precipitate is obtained, but is of doubtful value in case one appears, for it may contain other elements, such as iron, which do not affect the results.

If phosphorus is known to be present, the method should be followed through the first addition of ammonia. If aluminum is indicated, re-acidify the solution with HCl, add macerated paper, two drops of methyl orange, and 10 cc. of a solution of diammonium phosphate (10-per-cent.) Render the solution just ammoniacal, then just restore the pink color with dilute HCl (1:3), heat to boiling, and add 30 cc. of a solution of ammonium acetate (25-per-cent). Boil for 5 minutes, filter on an 11-cm. No. 42 Whatman or similar filter paper, and wash with hot ammonium nitrate solution (5-per-cent) until 5 cc. of the washings no longer give a test for chlorides with acidified silver nitrate. Ignite in platinum or porcelain, heat at approximately 1100° C. for 10 minutes, and weigh as $AlPO_4$. This method is not strictly accurate on account of the uncertain composition of the phosphate, but is sufficiently accurate for all but the most painstaking analyses.

C. CEMENT, LIME, GYPSUM AND CLAY PRODUCTS

STANDARD SPECIFICATIONS AND TESTS FOR PORTLAND CEMENT

(SERIAL DESIGNATION: C 9 - 26)[1]

A revision in the form of a separate tentative specification entitled "Specifications and Tests for Compressive Strength of Portland-Cement Mortars (C 9 - 16 T)"[2] is intended to become a part of the present standard specifications.

STANDARD SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE

(SERIAL DESIGNATION: C 14 - 24)[3]

Section 1.—Add the following footnote:

"***Caution.***—The consumer or purchaser is cautioned against using cement-concrete pipe where the sewage shows an acid reaction."

STANDARD SPECIFICATIONS FOR GYPSUM PLASTERS

(SERIAL DESIGNATION: C 28 - 21)[4]

Section 3.—Change the second and third sentences of Paragraph (*a*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"The [remainder] *other 33.3 per cent* shall contain not less than [75] *60.5* per cent [of its] *by* weight of calcined gypsum *calculated from the* SO_3 *content.* The [other 25 per cent of this] remainder may consist of materials to control the working quality, setting time, and the fibering.[1]"

Change the second and third sentences of Paragraph (*b*) to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"The [remainder] *other 25 per cent* shall contain not less than [75] *60.5* per cent by weight of calcined gypsum, *calculated from the* SO_3 *content.* The [other 25 per cent of this] remainder may consist of materials to control the working quality, setting time, and the fibering.[1]"

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[1] A.S.T.M. Standards Adopted in 1926. Criticisms of this revision are solicited and should be directed to Mr. F. H. Jackson, Secretary of Committee C-1 on Cement, U. S. Bureau of Public Roads, Washington, D. C.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. XX, Part I, p. 599 (1920); also 1926 Book of A.S.T.M. Tentative Standards, p. 242.

[3] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. E. S. Rankin, Secretary of Committee C-4 on Clay and Cement-Concrete Sewer Pipe, Engineer in Charge, Bureau of Sewers, City Hall, Newark, N. J.

[4] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, The Gypsum Industries, 844 Rush St., Chicago, Ill.

Section 6.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"Gypsum neat plaster is a plastering material in which not less than [85] *60.5* per cent of the cementitious material is calcined gypsum, *calculated from the SO_3 content, and* mixed at the mill with other materials."

Section 7.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"Gypsum neat plaster shall contain not less than [85] *60.5* per cent by weight of calcined gypsum, *calculated from the SO_3 content.* The remainder may consist of materials to control the working quality, setting time, and fibering.[1]"

Section 8.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"Gypsum neat plaster *when mixed with three parts by weight of testing sand* shall set in not less than [1½] *8* hours *nor more than 32 hours.*"

Section 11.—Change to read as follows by the addition of the italicized words and the omission of those in brackets:

"Gypsum wood-fibered plaster shall contain not less than [80] *60.5* per cent by weight of calcined gypsum, *calculated from the SO_3 content* and not less than 1 per cent by weight of wood fiber made from a non-staining wood. The remainder may consist of materials to control the working quality and setting time."

STANDARD SPECIFICATIONS FOR GYPSUM PARTITION TILE OR BLOCK

(SERIAL DESIGNATION: C 52 – 25)[1]

It is recommended that the last sentence of Section 14 (*c*) be changed to read as follows by the addition of the italicized words and the omission of those in brackets:

"When neat gypsum mortar is used for bedding and capping the test may be conducted after the mortar has set, but not sooner than [one hour] *twenty-four hours* after the sample has been capped."

STANDARD SPECIFICATIONS FOR PAVING BRICK

(SERIAL DESIGNATION: C 7 – 15)[2]

In the Appendix to the specifications, eliminate one of the recognized sizes and types of paving brick, making the recommendations for sizes read as follows:

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[1] A.S.T.M. Standards Adopted in 1925. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, The Gypsum Industries, 844 Rush St., Chicago, Ill.

[2] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. W. McBurney, Secretary of Committee C-3 on Brick, U. S. Bureau of Standards, Washington, D. C.

	WIDTH, IN.	DEPTH, IN.	LENGTH IN.
Plain wire-cut brick (vertical fiber, lugless).......	3[a]	4[a]	8½
Plain wire-cut brick (vertical fiber, lugless).......	3½[a]	4[a]	8½
Repressed lug brick..........................	3½	4	8½
Wire-cut lug brick (Dunn)....................	3½	4	8½

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[a] These bricks are customarily laid in the pavement to give a depth of 3 or 3½ in., respectively, by 4 in. in width and 8½ in. in length.

STANDARD SPECIFICATIONS FOR HYDRATED LIME FOR STRUCTURAL PURPOSES

(SERIAL DESIGNATION: C 6 – 24)[1]

Section 12.—Change the second and fifth paragraphs from their present form: namely,

"The lime shall be made into a stiff putty with water and permitted to soak over night. It shall be molded in a rubber ring such as is used with a Vicat needle, resting the specimen on a glass plate."

"If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared."

to read respectively as follows:

"The lime shall be made into a stiff putty with water, stirred vigorously with a trowel or spatula for three minutes and permitted to soak over night. It shall be stirred vigorously with a trowel or spatula for three minutes, molded in a rubber ring such as is used with a Vicat needle, resting the specimen on a glass plate."

"If the penetration is less than standard, the sample may be removed from the mold, mixed with more water, stirred vigorously with a trowel or spatula for three minutes, and retested. If the penetration is more than standard, the sample shall be discarded and a new one prepared."

STANDARD METHODS OF TESTING GYPSUM AND GYPSUM PRODUCTS

(SERIAL DESIGNATION: C 26 – 23)[2]

Add the following sections to the present Standard Methods:

XII. COMPRESSIVE STRENGTH OF GYPSUM PARTITION TILE OR BLOCK

23. (*a*) Not less than ten full-size gypsum tile specimens shall be used.

(*b*) The test specimens shall be dried to constant weight at a temperature not exceeding 110° F. (43° C.), until two successive weighings of the same specimen do not show a variation in excess of 0.5 per cent. At the option of the manufacturer or purchaser, strength tests may be conducted on samples that are dried at room temperature. However, in cases of controversy all test samples shall be dried to constant weight as herein prescribed.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. S. Elwell, Secretary of Committee C-7 on Lime, National Lime Association, 918 G St., N. W., Washington, D. C.

[2] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, The Gypsum Industries, 844 Rush St., Chicago, Ill.

(*c*) The tile or block shall be tested in the position in which they are designed to be used and shall be bedded on and capped with a felt gasket not less than $\frac{1}{8}$ in. nor more than $\frac{1}{4}$ in. in thickness. At the option of the manufacturer or purchaser, or in cases of controversy, the test samples may be suitably bedded and capped with neat gypsum mortar, or the bearing surfaces of the tile may be planed or rubbed smooth and true. When neat gypsum mortar is used for bedding and capping, the test may be conducted after the mortar has set, but not sooner than one hour after the sample has been capped.

(*d*) The loading head shall completely cover the bearing area of the tile, and the applied load shall be transmitted through a spherical bearing block of proper design. The speed of the moving head of the testing machine shall not be more than 0.05 in. per minute.

XIII. TRANSVERSE STRENGTH OF GYPSUM PARTITION TILE OR BLOCK

24. (*a*) Not less than ten full-size gypsum tile specimens shall be used.

(*b*) The test specimens shall be dried to constant weight as prescribed for the determination of the compressive strength.

(*c*) The tile or block shall be supported on its face (flat) on fixed parallel bearings spaced 24 in. (600 mm.) on centers, and shall be loaded through a similar bearing midway between the supports. All bearing and load surfaces shall be true, shall engage the full width of the test specimen, and shall be rounded to a radius of $\frac{1}{2}$ in. (12.7 mm.).

(*d*) The speed of the moving head of the testing machine shall not be more than 0.05 in. per minute. The modulus of rupture shall be calculated in pounds per square inch from the formula:

$$\text{Modulus of Rupture} = \frac{3wl}{2bd^2}$$

where l = distance between supports in inches;
b = breadth (width) of tile in inches;
d = thickness of tile in inches;
w = load in pounds at failure of test specimen.

XIV. ABSORPTION OF GYPSUM PARTITION TILE OR BLOCK

25. (*a*) The absorption shall be determined upon a test specimen of partition tile or block consisting of approximately one-half of a full-size tile.

(*b*) The test specimen shall be dried to constant weight as prescribed for the determination of the compressive strength.

(*c*) The dried test specimen shall be submerged in water until a constant saturated weight is attained, but in no event for a period of less than two hours, the water temperature being maintained at between 70 and 80° F. (21 and 27° C.). The test specimen shall be removed, the surface wiped off with a damp cloth and the specimen weighed immediately. The percentage of absorption shall be calculated on the dry weight from the formula:

$$\text{Percentage of Absorption} = \frac{100\,(B-A)}{A}$$

where A = weight of dry test specimen;
B = weight of saturated test specimen.

(*d*) The rate of absorption shall be determined by sealing upon the face of the test specimen, which shall first be dried to constant weight as prescribed for determination of the compressive strength, a glass tube 1½ in. in diameter and 12 in. in length, graduated in centimeters and located centrally over a core. Into this tube shall be poured 250 cc. of water at a temperature of between 70 and 80° F. (21 and 27° C.). The rate of absorption shall be reported in cubic centimeters per minute.

XV. TRANSVERSE STRENGTH OF GYPSUM BOARDS

26. (*a*) Test specimens shall be taken from not less than ten gypsum boards.

(*b*) Strength test specimens shall be 12 in. (300 mm.) in width and approximately 18 in. (460 mm.) in length. They shall be supported on fixed parallel bearings spaced 16 in. (410 mm.) on centers, and shall be loaded through a similar bearing midway between the supports. All bearing and load surfaces shall be true, shall engage the full width of the test specimen, and shall be rounded to a radius of ⅛ in. (3.2 mm.).

(*c*) Test loads shall be applied at a uniform rate of 60 lb. (27.22 kg.) per minute with a permissible variation of ± 10 per cent in the rate. Strength test results shall be reported when the load is applied across the fiber of the surfacing and also parallel to the fiber of the surfacing.

STANDARD DEFINITIONS FOR CLAY REFRACTORIES

(SERIAL DESIGNATION: C 27 – 20)[1]

Omit Section 3 comprising the reference to the test to be used for linear contraction or expansion, and Sections 5, 9, 11 and 13 covering the requirements in the case of clay brick, siliceous brick, intermediate duty brick and moderate duty brick, respectively. Renumber the remaining sections accordingly.

STANDARD DEFINITIONS OF TERMS RELATING TO THE GYPSUM INDUSTRY

(SERIAL DESIGNATION: C 11 – 26)[2]

Revisions in the form of tentative definitions of terms entitled "Definitions of Terms Relating to the Gypsum Industry (C 11 – 26 T)"[3] are intended to become a part of the present standard definitions.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. L. J. Trostel, Secretary of Committee C-8 on Refractories, General Refractories Co. Laboratories, P. O. Box 935, Baltimore, Md.

[2] A.S.T.M. Standards Adopted in 1926. Criticisms of this revision are solicited and should be directed to Mr. H. J. Schweim, Secretary of Committee C-11 on Gypsum, The Gypsum Industries, 844 Rush St., Chicago, Ill.

[3] See p. 786.

D. MISCELLANEOUS MATERIALS

STANDARD SPECIFICATIONS FOR PURITY OF RAW LINSEED OIL FROM NORTH AMERICAN SEED

(SERIAL DESIGNATION: D 1 – 15)[1]

Revisions in the form of separate tentative specifications entitled "Specifications for Raw Linseed Oil (D 234 – 26 T)"[2] are intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR BROKEN SLAG FOR WATERBOUND BASE AND WEARING COURSE

(SERIAL DESIGNATION: D 65 – 23)[3]

Section 4.—Omit this section, reading as follows, renumbering the succeeding sections accordingly:

"The percentage of wear shall be not more than 12.0 per cent."

Section 6.—Change the last line of this section to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"[Retained on] *Passing* 2½-in. screen . . . not [less] *more* than [85] *15* per cent."

Section 7 (b).—Omit this paragraph which refers to the method of testing the percentage of wear.

STANDARD SPECIFICATIONS FOR SHOVEL-RUN OR CRUSHER-RUN BROKEN SLAG FOR WATERBOUND BASE

(SERIAL DESIGNATION: D 66 – 23)[3]

Section 4.—Omit this section, reading as follows, renumbering the succeeding sections accordingly:

"The percentage of wear shall be not more than 15.0 per cent."

Section 6 (b).—Omit this paragraph which refers to the method of testing the percentage of wear.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, National Lead Co., 105 York St., Brooklyn, N. Y.

[2] See. p. 788.

[3] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, The Asphalt Association, 441 Lexington Ave., New York City.

STANDARD SPECIFICATIONS FOR YELLOW-PINE BRIDGE AND TRESTLE TIMBERS

(SERIAL DESIGNATION: D 10 - 15)[1]

Revisions in the form of separate tentative specifications entitled "Specifications for Structural Joist, Planks, Beams, Stringers and Posts (D 245 - 26 T)"[2] are intended to replace the present standard specifications.

STANDARD SPECIFICATIONS FOR SOUTHERN YELLOW-PINE TIMBER TO BE CREOSOTED

(SERIAL DESIGNATION: D 24 - 20)[1]

Revisions in the form of separate tentative specifications entitled "Specifications for Structural Joist, Planks, Beams, Stringers and Posts (D 245 - 26 T)"[2] are intended to replace the present standard specifications.

STANDARD METHODS OF TESTING OLEO-RESINOUS VARNISHES

(SERIAL DESIGNATION: D 154 - 24)[3]

A revision in the form of a separate tentative method of test entitled "Method of Test for Elasticity or Toughness of Varnishes by Means of Addition of Linseed Oil (D 154 - 26 T)"[4] is intended to become a part of the present standard methods.

STANDARD METHOD OF TEST FOR DISTILLATION OF BITUMINOUS MATERIALS SUITABLE FOR ROAD TREATMENT

(SERIAL DESIGNATION: D 20 - 18)[5]

A revision in the form of a separate tentative method of test entitled "Method of Test for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 - 26 T)"[6] is intended to replace the present standard methods.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

[2] See p. 906.

[3] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, National Lead Co., 105 York St., Brooklyn, N. Y.

[4] See p. 814.

[5] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, The Asphalt Association, 441 Lexington Ave., New York City.

[6] See p. 881.

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COKE

(SERIAL DESIGNATION: D 37 - 24)[1]

On page 1014 of the 1924 Book of A.S.T.M. Standards under "A Small Riffle Sampler," change "No. 10" to read "No. 20." Also change the paragraphs under "Roll Crusher" and under "Abbe Ball Mill or Hard-Steel Diamond Mortar" to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "*Hard-Steel* Roll Crusher.—For reducing the product passing a No. 4 sieve to pass a [No. 10] *No. 20* sieve."
>
> "Abbe Ball Mill, *Hard-Steel Roll Crusher*, or Hard-Steel Diamond Mortar.—For reducing the product passing a [No. 10] *No. 20* sieve to pass a No. 60 sieve. The porcelain jars for the ball mill should be approximately 9 in. in diameter and 10 in. high. The flint pebbles should be smooth, hard, and well rounded. *The rolls of the hard-steel roll crusher should revolve at the same speed.*"

On page 1016 under "Reduction of Sample," line 9, change "No. 10 sieve" to read "No. 20 sieve;" also change "400 g." in lines 9 and 10 to read "200 g."

Change the last two sentences of the first paragraph under "Reduction of Sample" from their present form: namely,

> "Reduce the quantity of sample by quartering or riffling to about 50 g. Pass the entire 50-g. portion through a No. 60 sieve, pulverizing any coarse particles in a diamond mortar, and mix with remainder of sample, preserving the sample for analysis in a rubber-stoppered glass bottle."

to read as follows:

> "Pass all the material through a No. 60 sieve, pulverizing any coarse particles by impact in a hard-steel diamond mortar, and mix with remainder of sample. Reduce the sample through small riffle sampler to about 50 g. and transfer to a rubber-stoppered glass bottle."

Change the last paragraph under "Reduction of Sample" to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

> "In case a ball mill is not available for fine grinding, quarter the 5-lb. sample passing a [No. 10] *No. 20* sieve to 200 g. and pulverize to pass a No. 60 sieve *by means of a hard-steel roll crusher in which the rolls revolve at the same speed, or* by impact in a hard-steel diamond mortar. The use of rubbing surfaces such as a disk pulverizer or a bucking board is never permissible for grinding coke."

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, 4800 Forbes St., Pittsburgh, Pa.

STANDARD METHODS OF LABORATORY SAMPLING AND ANALYSIS OF COAL

(SERIAL DESIGNATION: D 22 – 24)[1]

On page 983 of the 1924 Book of A.S.T.M. Standards, under "Method of Sampling, (*A*) When Coal Appears Dry," line 12, change "120 g." to read "200 g."; also change "60 g." in line 6 to read "50 g." and on page 984, line 3, change "60 g." to read "about 50 g."

On pages 994 to 998 of the 1924 Book of A.S.T.M. Standards change the paragraphs now given under "Apparatus" to read as follows:

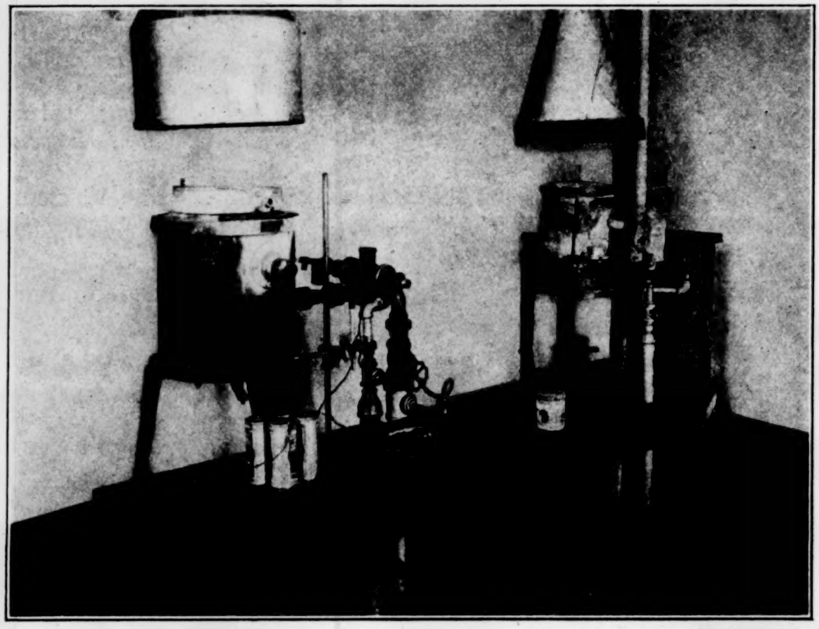

FIG. 3.—Denver Fire-Clay Furnace and No. 3 Melter's Furnace, with Accessories

"*Standard Furnace.*—Gas-fired furnaces such as the coal-ash fusion furnace of the Denver Fire Clay Co., the No. 3 Melter's Furnace of the American Gas Furnace Co., or their equivalent shall be used.

"These gas-fired furnaces are especially suitable for fusion determination in that the burners are arranged on a tangent near the base of the furnace, thus producing a rotary flame which completely surrounds the crucible in which the ash cones are placed. The whirling flame heats the crucible uniformly and when the furnaces are operated with an excess of gas over air, a reducing atmosphere is maintained in the crucible, which condition gives the lowest point at which the ash fuses. Either natural or artificial gas may be used. Air should be supplied at uniform pressure.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. W. A. Selvig, Secretary of Committee D-5 on Coal and Coke, 4800 Forbes St., Pittsburgh, Pa.

"The stock design of the No. 3 Melter's Furnace should be modified by providing the upper cylinder with two holes in the side; a 2-in. observation hole with its center 4 in. from the top of the cylinder (excluding cover plate), and a 1-in. thermocouple hole 90 deg. to the right of the observation hole; the bottoms of these holes being in the same horizontal plane. The coal-ash fusion furnace as furnished by the Denver Fire Clay Co. is provided with suitable observation and thermocouple holes. The interior of the furnaces are cylindrical and approximately 7 in. in diameter. Counter-balanced sheet-iron canopies connected with telescopic flues to an exhaust system are placed over the furnaces for conducting the hot gases out of the room. Two furnaces and accessories are shown in Fig. 3

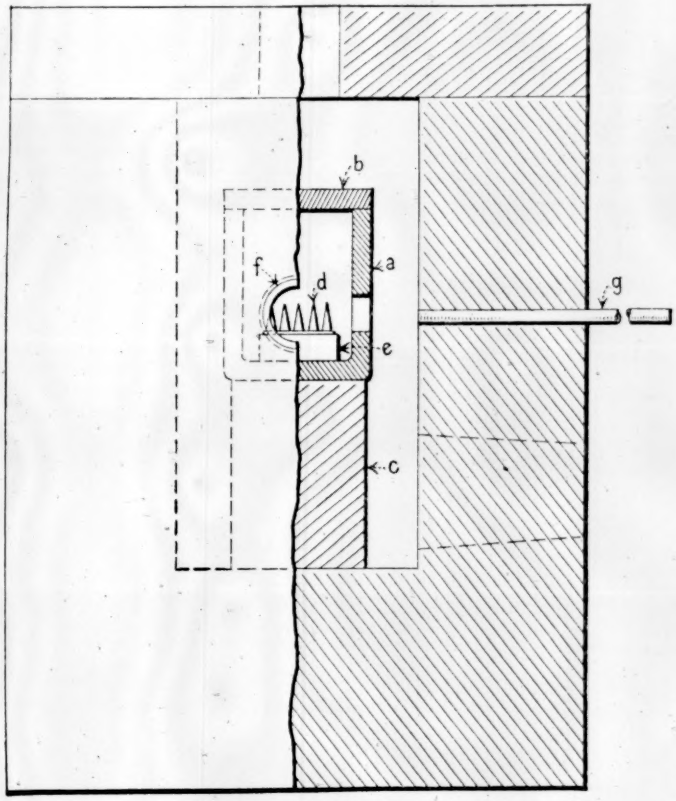

FIG. 4.—Section of Furnace Arranged for Fusion Tests.

"*Refractory Crucibles.*—The interior of the coal-ash fusion furnace as arranged for making a test is shown in Fig. 4. Crucible *a* is a Corundite crucible about 3 in. in inside diameter and about 4½ in. in height outside, with a wall thickness of about ½ in. The crucible is provided with a cover, *b*, and should have two holes in the side, an observation hole 2 in. in diameter and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottoms of the two holes should be in the same horizontal plane. The crucible is supported by Corundite support, *c*, so that the two holes in the crucible are in line with the corresponding holes in the furnace wall. The ash cones, *d*, are supported on Corundite disk *e* so that they are visible through the observation hole of the crucible and furnace wall.

"*Observation Hole.*—A fused silica, alundum, or refractory porcelain tube, *f*, $1\frac{7}{8}$ in. in external diameter and 6 to 7 in. long, is cemented in the 2-in. observation hole of the furnace, the inner end being flush with the inside furnace wall and the other end projecting out of the furnace. A brass sleeve carrying a thin glass window is slipped on the outer end of the observation tube to prevent the escape of burning gas, which would interfere with a convenient observation of the cones. When observations at high temperatures are made, the cones are viewed through a piece of colored glass.

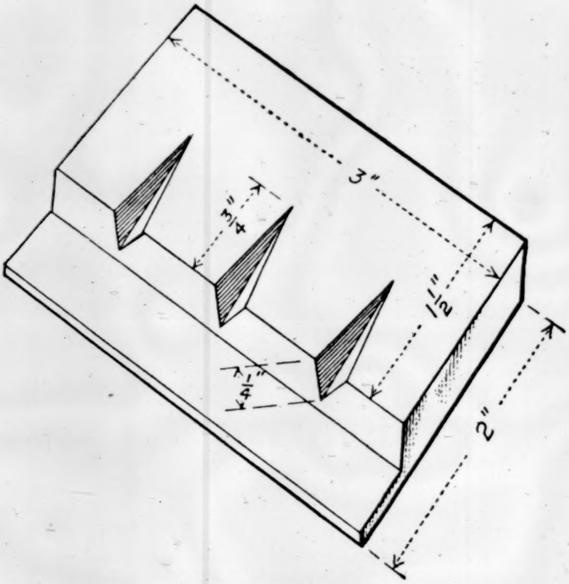

FIG. 5.—Brass Cone Mold.

"*Blowing Tube.*—At furnace temperatures above 1000° C. it is very difficult to observe the ash cones. An open refractory porcelain blowing tube, *g* (Fig. 4), about $\frac{1}{4}$ in. in inside diameter is inserted in the thermocouple hole, the inner end being flush with the inside of the furnace wall. The blowing tube is connected to the compressed air line by means of rubber tubing and the air is let into the tube at the time of observation by means of a pinchcock, thus momentarily cooling the ash cones and rendering them visible.

"*Brass Cone Mold.*—A brass cone mold for making ash cones, $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. at each side of base, which is an equilateral triangle, is illustrated in Fig. 5.

"*Pyrometer.*—Temperature measurements shall be made with a thermocouple of platinum and platinum-rhodium used in conjunction with a high-resistance millivoltmeter or potentiometer; or with an optical pyrometer of the disappearing filament type, which has been calibrated to be accurate to 10° C. up to 1400° C. and to 15° C. from 1400 to 1600° C. If a thermocouple is used it should be protected from the furnace gases by a glazed porcelain tube and so placed in the furnace that the hot junction is in the immediate vicinity of the cones. The pyrometer equipment should be checked frequently by mounting small pieces of pure gold and nickel in the same manner as the cones. With a strong reducing atmosphere, 1452° C. should be obtained for the melting point of nickel and 1063° C. for the gold. The pyrometer equipment should also be standardized from time to time through the temperature range for which it is used, by a suitably equipped standardizing laboratory, such as that of the U. S. Bureau of Standards."

On pages 987, 990, 993, 1000, and 1012 of the 1924 Book of A.S.T.M. Standards omit the permissible differences in duplicate determinations as given and in place thereof add the following section at the end of the standard methods:

TOLERANCES

The permissible differences between two or more determinations shall not exceed the values as specified.

A. On laboratory samples, crushed to pass through a No. 20 sieve.

	PERMISSIBLE DIFFERENCES	
	SAME LABORATORY	DIFFERENT LABORATORIES
MOISTURE:		
Under 5 per cent	0.2	0.3
Over 5 "	0.3	0.5

B. On laboratory samples, crushed to pass through a No. 60 sieve.

	PERMISSIBLE DIFFERENCES	
	SAME LABORATORY	DIFFERENT LABORATORIES
1. MOISTURE:		
Under 5 per cent	0.2	0.3
Over 5 "	0.3	0.5
2. ASH:		
No carbonates present	0.2	0.3
Carbonates present	0.3	0.5
Coals with more than 12 per cent of ash, containing carbonate and pyrite	0.5	1.0
3. VOLATILE MATTER:		
Bituminous coals	0.5	1.0
Lignites	1.0	2.0
4. SULFUR:		
Under 2 per cent	0.05	0.10
Over 2 "	0.10	0.20
5. ULTIMATE ANALYSIS:		
Carbon	0.3	....
Hydrogen	0.07	....
Nitrogen	0.05	....

6. CALORIMETRIC DETERMINATION:		
Permissible differences in per cent	0.3	0.5
7. FUSIBILITY OF COAL ASH:		
Permissible differences in deg. Cent	30	50

STANDARD METHODS OF SAMPLING AND ANALYSIS OF CREOSOTE OIL

(SERIAL DESIGNATION: D 38 – 24)[1]

A revision in the form of a separate tentative method of test entitled "Method of Test for Coke Residue of Creosote Oil (D 168 – 23 T)"[2] is intended to become a part of the present standard methods.

A revision in the form of a separate tentative method of test entitled "Method of Test for Distillation of Creosote Oil (D 246 – 26 T)"[3] is intended to replace the present Method of Test for Distillation appearing as Sections 10 to 12 of the standard methods.

STANDARD METHODS OF TESTING MOLDED INSULATING MATERIALS

(SERIAL DESIGNATION: D 48 – 24)[4]

Section 2.—Change the first sentence to read as follows by the addition of the italicized words:

"Any standard testing machine may be used ***provided the error in the loading range does not exceed 1 per cent.***"

Section 3.—Change the second sentence to read as follows by the addition of the italicized word and the omission of those in brackets:

"It shall be molded in a hardened [and ground] steel mold ***ground*** to the dimensions given in Fig. 1."

Section 4.—Omit the second and third paragraphs reading as follows:

"Three specimens shall be tested after heating in an oven for one hour at a temperature which is 10° C. (18° F.) below the distortion point of the material, as determined in accordance with Sections 18 to 21. Each specimen shall be taken from the oven and tested immediately while hot.

"Two specimens shall be tested after they have been entirely immersed in water for 48 hours at normal room temperature. The specimens shall be pulled apart at normal room temperature of about 20° C. (68° F.) after the surface water has been removed by wiping with a dry cloth."

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. A. Newlin, Secretary of Committee D-7 on Timber, U. S. Forest Products Laboratory, Madison, Wis.

[2] *Proceedings*, Am. Soc. Testing Mats., Vol. 23, Part I, p. 771 (1923); also 1926 Book of A.S.T.M. Tentative Standards, p. 700.

[3] See p. 943.

[4] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

Change the first sentence of Paragraph (*b*) from its present form: namely,

> "The test specimen shall be pulled apart at such a speed that the beam can be kept well balanced."

to read as follows:

> "The speed of the head of the testing machine shall be such that the load can be accurately weighed but shall not exceed 0.050 in. (1.27 mm.) per minute with the machine running idle."

Fig. 1.—Indicate the location of the $1\frac{3}{4}$-in. radius as $\frac{15}{16}$ in. above the bottom of the grip and $\frac{7}{8}$ in. on either side of the center line.

Fig. 2.—Change from a cube to a cylinder having a height of 1.25 in. (3.18 cm.) and a diameter of 1.125 in. (2.86 cm.). Omit the words "Manufacturer's Name and 'Test Specimen No. 3' Molded on Top in Small Round Body Raised Letters."

Section 6.—Change from its present form: namely,

> "Any standard testing machine may be used. The pressure head used for standard compressive strength tests of cement blocks is satisfactory for this purpose. A sheet of soft annealed copper about $\frac{1}{32}$ in. (1 mm.) thick, or heavy blotting paper, shall be placed above and below the specimen to equalize irregularities."

to read as follows:

> "Any standard testing machine may be used provided it is accurate to within 1 per cent for the lowest load for which it is used. One end of the specimen shall bear upon an accurately centered spherical bearing block, located whenever practicable at the top and the metal bearing plates shall be directly in contact with the ends of the test specimen. The pressure heads used for standard compression tests of cement (see Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars (Serial Designation: C 9 - 16 T) of the American Society for Testing Materials) are satisfactory for this test."

Section 7.—In the first sentence, change the word "cube" to "cylinder." Add a new sentence to read as follows:

> "The ends shall be flat and perpendicular to the axis, being ground to this condition if necessary."

Section 8.—Omit the second and third paragraphs, reading as follows:

> "Three specimens shall be crushed after heating for one hour at a temperature which is 10° C. (18° F.) below the distortion point of the material as determined in accordance with Sections 18 to 21. Each specimen shall be taken from the oven and tested immediately while hot.

"Two specimens shall be crushed after immersion in water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth."

Insert new paragraphs to read as follows:

"Additional tests shall be made at elevated temperatures, the actual temperatures selected depending upon the use that is to be made of the material. Five specimens shall be tested at each temperature selected. The specimen shall be kept at that temperature a sufficient length of time to become of uniform temperature throughout and shall be maintained at that temperature during the test.

"NOTE 1.—A convenient method of making this test is to submerge the specimens in a suitably lagged, electrically heated oil bath of about two gallons capacity. The specimens should be placed in the bath at least one-half hour before testing and the temperature maintained approximately constant at the desired testing temperature until the completion of that test. A pale mineral oil having a viscosity of 100 seconds ±10 seconds at 38° C. (100° F.) Saybolt is satisfactory for this purpose. The specimens should not be placed in the oil an excessive time in advance of testing. The oil bath should be well stirred to insure uniform temperature throughout. The temperature should be determined by means of a thermocouple sealed in a similar specimen in the bath; or by the use of an A.S.T.M. partial immersion thermometer conforming to the Standard Specifications for A.S.T.M. Partial-Immersion Thermometer for General Use, -20 to $+150°$ C., 0 to $+300°$ F. (Serial Designation: D 182) of the American Society for Testing Materials,[1] so inserted in a hole in a specimen that the bulb is completely enclosed and sealed in.

"If tests are required over the whole range of temperature rather than at particular points, the method of testing may be found simpler and quicker if modified in accordance with Note 2, below.

"NOTE 2.—The oil with 5 specimens immersed in it should be heated to the highest temperature to be used and allowed to cool slowly. Specimens should be tested in succession and the average temperature during the actual time of testing of each specimen taken as that corresponding to each strength determination. Specimens should be added to the bath successively on such a schedule that each will remain in the bath at least ½ hour before testing. An average curve shall be drawn through the plotted data."

Change the first sentence of Paragraph (*b*) from its present form: namely,

"The load shall be applied in a direction at right angles to that in which the pressure was applied in molding, and at such a rate of speed that will permit the beam to be kept well balanced from zero load until the specimen is crushed."

to read as follows:

"The load shall be applied on the ends of the specimen and the cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced but shall not exceed 0.050 in. (1.27 mm.) per minute when the machine is running idle."

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[1] **A.S.T.M. Standards Adopted in 1925.**

In Paragraph (*e*), change the word "jaws" to read "head." Add a new sentence to read as follows:

"The time required for testing each specimen should be recorded."

Section 10.—Change to read as follows:

"Any standard testing machine may be used provided it is accurate to within 1 per cent for the lowest load for which it is used. The distance between points of support shall be 4 in. (10.16 cm.). The supports shall have the contact edges rounded to a radius of $\frac{1}{8}$ in. (3.18 mm.). The load shall be applied midway between the supports by a pressure piece, the bearing edge of which shall be rounded to a radius of $\frac{1}{8}$ in. (3.18 mm.)."

Section 12.—In the first sentence of Paragraph (*a*) change the words "four specimens" to read "five specimens."

Change the second paragraph from its present form: namely,

"Three specimens shall be tested after immersion in water at normal room temperature for 48 hours with all surface water wiped off with a dry cloth."

to read as follows:

"Additional tests shall be made at elevated temperatures as outlined in Section 8."

Change the first two sentences of Paragraph (*b*) from their present form: namely,

"The load shall be applied at as slow a speed as possible, so that the beam may be kept well balanced from zero load until the first sign of failure. All tests shall be made at room temperature of about 20° C. (68° F.)."

to read as follows:

"The cross-head speed of the testing machine shall be such that the beam of the machine can be kept balanced but shall not exceed 0.050 in. (1.27 mm.) per minute when the machine is running idle."

Section 13.—Change Paragraph (*e*) to read as follows by the addition of the italicized word and the omission of those in brackets:

"The [amount of] ***maximum*** deflection at the center in inches or in millimeters."

Omit Paragraph (*f*) reading as follows:

"The distance between the supports in inches or in millimeters."

Section 16 (*b*).—Change the second paragraph from its present form: namely,

"Three specimens shall be punctured after heating one hour in an oven heated to 10° C. (18° F.) below the distortion point of the material as determined in Sections 18 to 21. The specimen shall be taken from the oven and immediately punctured in air while hot. This test is intended to cover all molded materials which do not withstand working temperatures above 125° C. (257° F.). Tests on materials which resist high temperatures may be made above 125° C. (257° F.) when required."

to read as follows:

"Additional tests shall be made at elevated temperatures, the actual temperatures selected depending upon the use that is to be made of the material. Five specimens shall be tested at each temperature while in an oven maintained at the proper temperature, either by hand adjustment or by automatic thermostat. Specimens shall be placed in the oven at least ½ hour previous to testing and the temperature shall then be maintained approximately constant at the testing temperature until the completion of that test. Temperature shall be determined by means of a thermocouple or a mercury thermometer placed in the oven close to the specimens and care shall be taken to avoid placing the specimens too close to the heater.

"Specimens with which arcing over the edge is encountered shall be tested under oil as described under Section 16, and in such cases the oil bath containing the specimens shall be installed in the oven and the temperature determined by immersing the thermometer in the oil."

In the third paragraph, change the words "Two specimens" to "Three specimens."

Section 17.—Add a new paragraph to read as follows:

"(*e*) Temperature at which each test was made."

Section 23.—Change to read as follows by the addition of the italicized words and figures and the omission of those in brackets:

"The test specimen [No. 1] *No. 3* shown in [Fig. 4] *Fig. 2* shall be used for this test. [After the puncture tests prescribed in Section 16 (*b*) are completed on the five specimens, three of them shall be taken and the entire rim of each specimen shall be sawed off with a hack saw ¼ in. (6 mm.) back from the top edge of the specimen so as to expose a more or less uniformly cut surface.]"

Section 24.—Change the first sentence from its present form: namely,

"Weigh each of the three test specimens after the rim has been sawed off."

to read as follows:

"Three specimens shall be tested. Weigh each of the three separately in the as-received condition."

In the fifth and sixth sentences change the words "100 hours" to "48 hours."

Section 25.—In paragraphs (*c*) and (*d*) change the words "100 hours" to "48 hours."

STANDARD METHODS OF TESTING TRANSFORMER AND SWITCH OILS

(SERIAL DESIGNATION: D 117 – 24)[1]

A revision in the form of separate methods of testing entitled "Methods of Testing Electrical Insulating Oils (D 117 – 26 T)"[2] is intended to replace the present standard methods.

STANDARD DEFINITIONS OF TERMS RELATING TO PAINT SPECIFICATIONS

(SERIAL DESIGNATION: D 16 – 24)[3]

Add the following three new definitions of terms:

Toughness.—Relative degree of resistance to impact without fracture; apposed to brittleness.

Elasticity of Paint and Varnish Films.—That property which allows a paint or varnish film to follow, without rupture, changes in the extent and form of the surface to which it is applied.

"*Screen* (*Sieve*).—A plate or sheet or woven cloth with regularly spaced apertures of uniform size, mounted on a suitable frame or holder, for use in separating materials according to size."

"NOTE.—The shape and spacing of apertures, size of wires or threads, thickness of plate or sheet, allowable variations and similar properties should be described in the specifications."

E. MISCELLANEOUS SUBJECTS

STANDARD METHODS OF VERIFICATION OF TESTING MACHINES

(SERIAL DESIGNATION: E 4 – 24)[4]

A revision in the form of a separate tentative method entitled "Method of Verification of Testing Machines by Means of an Elastic Calibration Bar (E 4 – 26 T)"[5] is intended to become a part of the present standard methods.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. T. S. Taylor, Secretary of Committee D-9 on Electrical Insulating Materials, Bakelite Corporation, 230 Grove St., Bloomfield, N. J.

[2] See p. 1021.

[3] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, National Lead Co., 105 York St., Brooklyn, N. Y.

[4] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. H. F. Moore, Chairman of Sub-Committee, of Committee E-1, on Mechanical Testing, University of Illinois, Urbana, Ill.

[5] See p. 1086.

STANDARD METHODS OF METALLOGRAPHIC TESTING OF NON-FERROUS METALS AND ALLOYS

(SERIAL DESIGNATION: E 5 - 24)[1]

Referring to the 1924 Book of Standards, the first sentence on page 1168 should be replaced by the following paragraph:

"For aluminum and its alloys, a solution of HF-HCl (Solution 2) is recommended. Ten-per-cent aqueous solution of NaOH and 10-per-cent HF also give good results. In copper-bearing alloys, the latter solution should be followed by a cleaning in cold concentrated HNO_3."

Under "Method of Polishing" on page 1168, the following paragraph should be added, covering the polishing of aluminum and its alloys:

"In the preparation of specimens of aluminum and its alloys, the same precautions must be followed which are recommended for other soft metals. It is further recommended that following the cut on the file, two coarse emery papers, No. 2 and No. 1, be used, preceding the use of the finer metallographic polishing papers. The papers should be prepared by applying a solution of paraffin in kerosine and working well into the surface. The polishing must be done by hand. The papers may be used either as so prepared or moistened with additional solution. It is not always necessary to use this solution on the coarse papers, No. 2 and No. 1. The hand polishing may be stopped at either No. 000 or No. 0000 paper and the polishing continued on a wheel revolving at approximately 200 r.p.m. For the first cut on the wheel, a coarse grade of broadcloth is used with a grade of abrasive similar to 65-*F* alundum. The next cut is made using a softer broadcloth and 'heavy magnesium oxide,' applied as follows: The pad is moistened with distilled water and approximately one teaspoonful of powder applied evenly to the surface and thoroughly rubbed in, all hard and coarse particles being brushed off with the hand. After the scratches left by the 65-*F* material have been removed the pad is washed clean and a smaller quantity of powder worked in as before. This time the cut is made at right angles to the first treatment. This procedure may be repeated several times until the specimen shows a brilliant, reflecting surface and under the microscope the aluminum solid solution matrix appears clear white and the constituents stand out in even colors, free from tarnish. Only distilled water should be used during the polishing with the magnesia powder, otherwise there is danger of forming particles of carbonate, which are harsh and scratch the specimen. It is good practice to frequently raise the specimen from the pad and revolve it 180 deg. before replacing. The pressure and quantity of water to be used can only be determined after considerable practice and varies with the nature of the alloy."

At the bottom of page 1169, it is recommended that the following paragraphs and table be inserted:

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, 967 Harrison Ave., Niagara Falls, N. Y.

"Etching reagents for the identification of constituents in aluminum and its alloys are generally unsatisfactory. Reagents intended to differentially color specific constituents are uncertain and their action varies in different alloys and especially under different conditions of polishing. For this reason it is recommended that the specimens be carefully polished and examined in the unetched condition. If a light filter is used to give a source of light approximating daylight, the constituents will appear as described below:

UNETCHED CHARACTERISTICS

Constituent	Color	Usual Shapes	Characteristics
Si	Slate.	Irregular plates.	Easily recognized.
$FeAl_3$	Purplish gray.	Needles.	Tendency to purple tinge with relief polishing.
Other iron constituents	Purplish gray.	"Chinese script" and needles.	Less tendency to purplish tinge. Occurrence due to other elements, notably Si. Composition uncertain.
$CuAl_2$	Clear with pink tinge.	Gobs, stringers.	Tendency to polish in relief and tarnish. Appears bright on passing out of focus.
$MnAl_3$	Flat gray to watery.	Angular plates, often hollow. Arrowheads.	Does not polish in relief, but prolonged polishing gives watery appearance. In high-manganese alloys shapes are very characteristic.
Mg_2Al_3	Very faint watery.	Gobs, stringers.	Same form as $CuAl_2$ but much softer. Sometimes difficult to distinguish from aluminum matrix.
$NiAl_3$	Light gray.	Needles.	Difficult to distinguish from $FeAl_3$.
Mg_2Si	Slate gray to iridescent blue.	Skeletons and rounded particles. Angular primary particles.	Very careful polish gives even slate-gray particles which are easily tarnished and are turned black or eaten out by too much water in polishing.

"With a little experience in the examination of specially prepared known standards, the identification of these constituents when they occur in sufficiently large particles is relatively simple and etching reagents for distinguishing them are generally unnecessary. When the particles are smaller, the identification becomes extremely difficult, but etching reagents which satisfactorily color large particles, fail to identify the smaller particles.

"In studying a specimen containing very small particles, such as finely precipitated $CuAl_2$, there may be sufficient surface flow to completely obscure the particles. To guard against this condition and to reveal grain boundaries and other structural features, it is desirable to swab the specimen lightly with a soft cotton swab saturated with a dilute solution of HF (0.5 to 1-per-cent preferred)."

Referring to page 1170, under the heading "Solutions for Aluminum and Its Alloys," the following list of etching reagents should be given, together with the specific use and the authority for the information:

	Reagent	Concentration	Specific Use	Authority	Reference Number
No. 1	HF and HCl[a]	10 to 20-per-cent alcoholic HF and concentrated HCl	Macroscopic	Czochralski	**(1)**
No. 2	HF and HCl[a]	10 parts HF, 15 parts HCl, 90 parts H_2O	Macroscopic	Flick	**(13)**
No. 3	HF	0.1 to 10-per-cent	General	Various	**(2,3, 4, 5, 6, 7, 11, 12, 14, 15, 16)**
No. 4	NaOH	0.1 to 10-per-cent	General	Various	**(2, 3, 4, 5, 6, 7, 11, 12, 14, 16)**
No. 5	NaOH	0.1 per cent in 10 to 50 per cent of alcohol	General	Merica	**(6, 7)**
No. 6	HNO_3	1 per cent in alcohol	Mg_2Al_3	Hanson	**(5)**
No. 7	HNO_3	10 per cent in alcohol	Mg_2Al_3	Hanson	**(5)**
No. 8	HNO_3[b]	20-per-cent Quench	$CuAl_2$	Hanson	**(5)**
No. 9	HNO_3[b]	25-per-cent Quench	"X" Const. from $FeAl_3$	Dix	**(9)**
No. 10	Ferric sulfate	10-per-cent	$CuAl_2$ from $FeAl_3$	R. J. Anderson	**(12)**
No. 11	Picric acid	4 per cent in alcohol	$CuAl_2$	A. Meyer	**(10)**
No. 12	H_2SO_4[b]	10-per-cent at 60 to 70° C.	$FeAl_3$	A. Meyer	**(10)**

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[a] Czochralski originally etched for grain by using from 10 to 20 per cent of concentrated HF in 100 cc. absolute alcohol, followed by dipping in concentrated HCl solution. Flick has very satisfactorily modified this etch by using a single solution prepared as follows: 10 cc. of commercial HF and 90 cc. of distilled water and 15 cc. of concentrated HCl.

[b] By the 20 and 25-per-cent nitric acid quench is meant the procedure of heating the solution to exactly 70° C. and immersing the specimen for a period from 2 or 3 seconds to 30 seconds and then immediately quenching the specimen in cold water. This same procedure may be used with the sulfuric acid etch, although the quench is not essential.

LIST OF REFERENCES

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STANDARD RULES GOVERNING THE PREPARATION OF MICROGRAPHS OF METALS AND ALLOYS, INCLUDING RECOMMENDED PRACTICE FOR PHOTOGRAPHY AS APPLIED TO METALLOGRAPHY

(SERIAL DESIGNATION: E 2 – 24)[1]

A revision in the form of a separate tentative recommended practice entitled "Recommended Practice for the Care of the Eyes when Using a Metallographic Microscope (E 2 – 26 T)"[2] is intended to be added as an appendix to the present standard rules.

STANDARD DEFINITIONS OF TERMS RELATING TO METALLOGRAPHY

(SERIAL DESIGNATION: E 7 – 24)[1]

A revision in the form of a separate tentative definition entitled "Definition of the Term Metallography (E 7 – 26 T)"[3] is intended to become a part of the present standard definitions.

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[1] 1924 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. G. F. Comstock, Secretary of Committee E-4 on Metallography, 967 Harrison Ave., Niagara Falls, N. Y.

[2] See p. 1098.

[3] See p. 1092.

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LIST OF A.S.T.M. STANDARDS[1]

As of September 1, 1926. Total Number, 270.

Published Collectively in their latest revised form in 1924 BOOK OF A.S.T.M. STANDARDS with 1925 and 1926 Supplements to the BOOK OF STANDARDS

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The designations A 1, A 2, etc., of the Standards are fixed; the final numbers 14, 24, etc., indicate the year of adoption as standard or, in the case of revision, the year of last revision. The serial designations of Standards, which have for any reason been discontinued, are permanently dropped. In ordering Standards, the complete serial designations should be stated, thus, A 1 - 24, A 2 - 24, etc.

A. FERROUS METALS

STEEL

See also **WROUGHT IRON:** A 56 - 24

STANDARD SPECIFICATIONS

Steel Rails and Accessories.

A 1 - 24. For Carbon-Steel Rails.
A 2 - 24. For the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types.
A 3 - 24. For Low-Carbon-Steel Splice Bars.
A 4 - 14. For Medium-Carbon-Steel Splice Bars.
A 5 - 14. For High-Carbon-Steel Splice Bars.
A 6 - 14. For Extra-High-Carbon-Steel Splice Bars.
A 49 - 21. For Quenched High-Carbon-Steel Splice Bars.
A 50 - 24. For Quenched Carbon-Steel Track Bolts.
A 51 - 21. For Quenched Alloy-Steel Track Bolts.
A 65 - 24. For Steel Track Spikes.
A 66 - 21. For Steel Screw Spikes.

Structural Steel.

A 7 - 24. For Structural Steel for Bridges.
A 8 - 24. For Structural Nickel Steel.
A 9 - 24. For Structural Steel for Buildings.
A 10 - 24. For Structural Steel for Locomotives.
A 11 - 24. For Structural Steel for Cars.
A 12 - 21. For Structural Steel for Ships.
A 13 - 24. For Rivet Steel for Ships.

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[1] For a complete list of standards and tentative standards with serial designations in continuous numeric sequence, see 1926 A.S.T.M. Year Book.

Spring Steel and Springs.

A 14 - 16. For Carbon-Steel Bars for Railway Springs.
A 68 - 18. For Carbon-Steel Bars for Railway Springs with Special Silicon Requirements.
A 58 - 16. For Carbon-Steel Bars for Vehicle and Automobile Springs.
A 59 - 16. For Silico-Manganese-Steel Bars for Automobile and Railway Springs.
A 60 - 16. For Chrome-Vanadium-Steel Bars for Automobile and Railway Springs.
A 61 - 16. For Helical Steel Springs for Railways.
A 62 - 16. For Elliptical Steel Springs for Railways.
A 69 - 18. For Elliptical Steel Springs for Automobiles.

Reinforcement Bars.

A 15 - 14. For Billet-Steel Concrete Reinforcement Bars.
A 16 - 14. For Rail-Steel Concrete Reinforcement Bars.

Steel Blooms, Forgings and Axles.

*A 17 - 21. For Carbon-Steel and Alloy-Steel Blooms, Billets and Slabs for Forgings.
*A 18 - 21. For Carbon-Steel and Alloy-Steel Forgings.
A 19 - 21. For Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars.
A 63 - 21. For Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars.
A 20 - 21. For Carbon-Steel Forgings for Locomotives.
A 21 - 18. For Carbon-Steel Car and Tender Axles.
A 22 - 21. For Cold-Rolled Steel Axles.

Steel Wheels and Tires.

A 25 - 24. For Wrought Solid Carbon-Steel Wheels for Electric Railway Service.
A 57 - 24. For Wrought Solid Carbon-Steel Wheels for Steam Railway Service.
A 26 - 16. For Steel Tires.

Steel Castings.

A 27 - 24. For Steel Castings.

Steel Tubes and Pipe.

A 83 - 24. For Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes.
A 53 - 24. For Welded and Seamless Steel Pipes.

Automotive Steels (see also **Spring Steel**).

A 29 - 24. For Automotive Carbon and Alloy Steels.

Boiler Steels.

A 30 - 24. For Boiler and Firebox Steel for Locomotives.
A 70 - 24. For Boiler and Firebox Steel for Stationary Service.
A 31 - 24. For Boiler Rivet Steel.

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* **Approved as** "Tentative American Standard" by the American Engineering Standards Committee.

Tool Steels.

A 71 - 26. For Carbon Tool Steel.
A 92 - 26. For High-Speed Tool Steel.

Bar Steels.

A 32 - 24. For Cold-Finished Bessemer Steel Automatic Screw Stock.
A 54 - 24. For Cold-Finished Open-Hearth Steel Automatic Screw Stock.
A 80 - 24. For Commercial Bar Steels.

Steel for High-Temperature Service.

A 96 - 26. For Alloy-Steel Bolting Material for High-Temperature Service.

Standard Methods

A 34 - 24. Of Test for Magnetic Properties of Iron and Steel.
A 33 - 24. Of Chemical Analysis of Plain Carbon Steel.
A 55 - 24. Of Chemical Analysis of Alloy Steels.
A 90 - 24. Of Determining Weight of Coating on Zinc-Coated Articles.
A 91 - 24. Of Determining Weight of Coating on Tin, Terne, and Lead-Coated Sheets.

Recommended Practice

A 35 - 24. For Annealing of Miscellaneous Rolled and Forged Carbon-Steel Objects.
A 36 - 24. For Heat Treatment of Carbon-Steel Castings.
A 37 - 14. For Heat Treatment of Case-Hardened Carbon-Steel Objects.

WROUGHT IRON

(See also **STEEL:** A 83 - 24)

Standard Specifications

A 72 - 24. For Welded Wrought-Iron Pipe.
A 84 - 24. For Staybolt, Engine-Bolt and Extra-Refined Wrought-Iron Bars.
*A 41 - 18. For Refined Wrought-Iron Bars.
A 85 - 24. For Merchant Bar Iron.
*A 42 - 18. For Wrought-Iron Plates.
A 73 - 24. For Wrought-Iron Rolled or Forged Blooms and Forgings for Locomotives and Cars.
A 56 - 24. For Iron and Steel Chain.

Standard Definitions

A 81 - 21. Of Terms Relating to Wrought-Iron Specifications.

PIG IRON, CAST IRON, AND FINISHED CASTINGS

Standard Specifications

A 43 - 24. For Foundry Pig Iron.
A 44 - 04. For Cast-Iron Pipe and Special Castings.
A 74 - 18. For Cast-Iron Soil Pipe and Fittings.

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.

A 45 - 14. For Cast-Iron Locomotive Cylinders.
A 46 - 24. For Chilled Cast-Iron Wheels.
A 47 - 24. For Malleable Castings.
A 48 - 18. For Gray-Iron Castings.
A 88 - 24. For High-Test Gray-Iron Castings.

STANDARD METHODS

A 64 - 16. Of Sampling and Chemical Analysis of Pig and Cast Iron.

B. NON-FERROUS METALS

STANDARD SPECIFICATIONS

Ingot Copper.

*B 4 - 13. For Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars.
*B 5 - 13. For Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars.

Spelter.

B 6 - 18. For Spelter.

Lead.

B 29 - 23. For Pig Lead.

Nickel.

B 39 - 22. For Nickel.

Aluminum.

B 26 - 21. For Light Aluminum Casting Alloys.
B 37 - 26. For Aluminum for Use in the Manufacture of Iron and Steel.

Wire and Cable.

B 49 - 26. For Hot-Rolled Copper Rods for Wire Drawing.
B 1 - 23. For Hard-Drawn Copper Wire.
B 2 - 15. For Medium Hard-Drawn Copper Wire.
*B 3 - 15. For Soft or Annealed Copper Wire.
B 33 - 21. For Tinned Soft or Annealed Copper Wire for Rubber Insulation.
B 8 - 21. For Bare Concentric-Lay Copper Cable: Hard, Medium-Hard, or Soft.
B 47 - 25. For Round and Grooved Hard-Drawn Copper Trolley Wire.
B 9 - 16. For High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity.

Bronze.

B 10 - 18. For the Alloy: Copper, 88 per cent; Tin, 10 per cent; Zinc, 2 per cent.
*B 30 - 22. For Brass Ingot Metal, Graded and Ungraded, for Sand Castings.
B 31 - 21. For Bronze Bearing Metal in Ingot Form.
B 22 - 21. For Bronze Bearing Metals for Turntables and Movable Railroad Bridges.

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.

White Metal.

*B 32 - 21. For Solder Metal.
B 23 - 26. For White Metal Bearing Alloys (known commercially as "Babbitt Metal").

Copper and Brass Plates, Tubes, Rods, etc.

B 11 - 18. For Copper Plates for Locomotive Fireboxes.
B 12 - 21. For Copper Bars for Locomotive Staybolts.
B 13 - 18. For Seamless Copper Boiler Tubes.
B 14 - 18. For Seamless Brass Boiler Tubes.
B 44 - 24. For Seamless Admiralty Condenser Tubes and Ferrule Stock.
B 55 - 25. For Seamless 70-30 Brass Condenser Tubes and Ferrule Stock.
B 56 - 25. For Seamless Muntz Metal Condenser Tubes and Ferrule Stock.
B 42 - 24. For Copper Pipe, Standard Sizes.
B 43 - 24. For Brass Pipe, Standard Sizes.
*B 15 - 18. For Brass Forging Rod.
*B 16 - 18. For Free-Cutting Brass Rod for Use in Screw Machines.
B 19 - 19. For Cartridge Brass.
B 20 - 19. For Cartridge Brass Disks.
*B 21 - 19. For Naval Brass Rods for Structural Purposes.
*B 36 - 21. For High Sheet Brass.

STANDARD METHODS

*B 34 - 20. Of Battery Assay of Copper.
B 35 - 24. Of Chemical Analysis of Pig Lead.
B 38 - 21. Of Chemical Analysis of Spelter.
B 41 - 23. Of Chemical Analysis of Nickel.
*B 18 - 21. Of Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper.
*B 27 - 19. Of Chemical Analysis of Manganese Bronze.
*B 28 - 19. Of Chemical Analysis of Gun Metal.
B 45 - 23. Of Chemical Analysis of Brass Ingots and Sand Castings.
B 46 - 23. Of Chemical Analysis of Bronze Bearing Metal.

C. CEMENT, LIME, GYPSUM, AND CLAY PRODUCTS

STANDARD SPECIFICATIONS

C 9 - 26. Specifications and Tests for Portland Cement.
C 10 - 09. For Natural Cement.
C 7 - 15. For Paving Brick.
C 21 - 20. For Building Brick.
C 32 - 24. For Clay Sewer Brick.
C 13 - 24. For Clay Sewer Pipe.
C 14 - 24. For Cement-Concrete Sewer Pipe.
†C 4 - 24. For Drain Tile.
C 5 - 26. For Quicklime for Structural Purposes.
C 6 - 24. For Hydrated Lime for Structural Purposes.

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.
† Approved as "American Standard" by the American Engineering Standards Committee.

C 45 – 25. For Quicklime and Hydrated Lime for Use in the Cooking of Rags for the Manufacture of Paper.
C 48 – 24. For Quicklime and Hydrated Lime for Use in the Textile Industry.
C 49 – 24. For Quicklime and Hydrated Lime for the Manufacture of Silica Brick.
C 22 – 25. For Gypsum.
C 23 – 22. For Calcined Gypsum.
C 28 – 21. For Gypsum Plasters.
C 35 – 25. For Gypsum Plastering Sand.
C 36 – 25. For Gypsum Wall Board.
C 37 – 25. For Gypsum Plaster Board.
C 52 – 25. For Gypsum Partition Tile or Block.
C 34 – 26. Specifications and Tests for Hollow Burned-Clay Load-Bearing Wall Tile.

Standard Methods

C 16 – 20. Of Test for Refractory Materials Under Load at High Temperatures.
C 20 – 20. Of Test for Porosity and Permanent Volume Changes in Refractory Materials.
C 24 – 20. Of Test for Softening Point of Fire-Clay Brick.
C 18 – 21. Of Ultimate Chemical Analysis of Refractory Materials, Including Chrome Ores and Chrome Brick.
*C 29 – 21. Of Test for Unit Weight of Aggregate for Concrete.
*C 30 – 22. Of Test for Voids in Fine Aggregate for Concrete.
C 31 – 21. Of Making and Storing Specimens of Concrete in the Field.
C 39 – 25. Of Making Compression Tests of Concrete.
*C 40 – 22. Of Test for Organic Impurities in Sands for Concrete.
C 41 – 24. Of Test for Sieve Analysis of Aggregates for Concrete.
C 26 – 23. Of Testing Gypsum and Gypsum Products.

Standard Definitions

C 8 – 24. Of Terms Relating to Sewer Pipe.
C 27 – 20. For Clay Refractories.
C 43 – 24. Of Terms Relating to Hollow Tile.
C 11 – 26. Of Terms Relating to the Gypsum Industry.

Recommended Practice

C 12 – 19. For Laying Sewer Pipe.

D. MISCELLANEOUS MATERIALS

PRESERVATIVE COATINGS

Standard Specifications

D 1 – 15. For Purity of Raw Linseed Oil from North American Seed.
D 11 – 15. For Purity of Boiled Linseed Oil from North American Seed.
D 13 – 26. For Gum Spirits of Turpentine and Steam-Distilled Wood Turpentine

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.

D 125 – 23. For Perilla Oil, Raw or Refined.
D 207 – 26. For Dry Bleached Shellac.
D 79 – 24. For Zinc Oxide.
D 80 – 24. For Leaded Zinc Oxide.
D 81 – 24. For Basic Carbonate White Lead.
D 82 – 24. For Basic Sulfate White Lead.
D 83 – 24. For Red Lead.
D 85 – 24. For Ocher.
D 208 – 26. For Lithopone.
D 209 – 26. For Lampblack.
D 210 – 26. For Bone Black.

STANDARD METHODS

D 233 – 26. Of Sampling and Testing Turpentine
D 153 – 24. Of Test for Specific Gravity of Pigments.
D 185 – 26. Of Test for Coarse Particles in Paint Pigments.
D 154 – 24. Of Testing Oleo-Resinous Varnishes.
D 154 – 25. Of Testing Oleo-Resinous Varnishes.[1]
D 29 – 24. Of Testing Shellac.
D 29 – 25. Of Test for Determination of Wax in Shellac.[2]
*D 56 – 21. Of Test for Flash Point of Volatile Flammable Liquids.
*D 34 – 17. Of Routine Analysis of White Pigments.
*D 49 – 18. Of Routine Analysis of Dry Red Lead.
*D 50 – 18. Of Routine Analysis of Yellow, Orange, Red and Brown Pigments Containing Iron and Manganese.
D 126 – 23. Of Routine Analysis of Yellow and Orange Pigments Containing Chromium Compounds, Blue Pigments and Chrome Green.
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D 16 – 24 Of Terms Relating to Paint Specifications.

PETROLEUM PRODUCTS AND LUBRICANTS

See also **PRESERVATIVE COATINGS:** D 56 – 21

STANDARD METHODS

D 47 – 24. Of Test for Specific Gravity of Lubricants.
D 206 – 25. Abridged Volume Correction Table for Petroleum Oils.
D 87 – 22. Of Test for Melting Point of Paraffin Wax.
D 88 – 26. Of Test for Viscosity of Petroleum Products and Lubricants.
D 92 – 24. Of Test for Flash and Fire Points by Means of Open Cup.
D 93 – 22. Of Test for Flash Point by Means of the Pensky-Martens Closed Tester.
D 95 – 24. Of Test for Water in Petroleum Products and Other Bituminous Materials.
D 96 – 24. Of Test for Water and Sediment in Petroleum Products by Means of Centrifuge.

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.

[1] To be added to the Standard Methods of Testing Oleo-Resinous Varnishes (Serial Designation: D 154 – 24) when the Book of Standards is next published.

[2] To be added to the present Standard Methods of Testing Shellac (Serial Designation: D 29 – 24) when the Book of Standards is next published.

ROAD MATERIALS

STANDARD SPECIFICATIONS

*D 57 – 20. For Materials for Cement Grout Filler for Brick and Stone Block Pavements.
D 58 – 24. For Materials for Cement Mortar Bed for Brick, Stone Block, Wood Block, Asphalt Block and Other Block Pavements.
D 59 – 26. For Block for Granite Block Pavements.
D 131 – 23. For Block for Recut Granite Block Pavements.
D 132 – 23. For Block for Durax Granite Pavements.
D 65 – 23. For Broken Slag for Waterbound Base and Wearing Course.
D 66 – 23. For Shovel-Run or Crusher-Run Broken Slag for Waterbound Base.

STANDARD METHODS

D 2 – 26. Of Test for Abrasion of Rock.
*D 3 – 18. Of Test for Toughness of Rock.
*D 30 – 18. Of Test for Apparent Specific Gravity of Course Aggregates.
D 55 – 25. Of Test for Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials.
D 72 – 21. Of Test for Quantity of Clay and Silt in Gravel for Highway Construction.
*D 75 – 22. Of Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, Including Some Material Survey Methods.
D 7 – 18. Of Mechanical Analysis of Sand or Other Fine Highway Material, except Fine Aggregates Used in Cement Concrete.
D 18 – 16. Of Mechanical Analysis of Broken Stone or Broken Slag, except Aggregates Used in Cement Concrete.
D 19 – 16. Of Mechanical Analysis of Mixtures of Sand or Other Fine Material with Broken Stone or Broken Slag, except Aggregates Used in Cement Concrete.
D 35 – 18. Form of Specifications for Certain Commercial Grades of Broken Stone.
D 5 – 25. Of Test for Penetration of Bituminous Materials.
D 6 – 20. Of Test for Loss on Heating of Oil and Asphaltic Compounds.
*D 20 – 18. Of Test for Distillation of Bituminous Materials Suitable for Road Treatment.
D 36 – 26. Of Test for Softening Point of Bituminous Materials (Ring-ante Ball Method).
D 61 – 24. Of Test for Softening Point of Tar Products (Cube-in-Ward-Method).
D 140 – 25. Of Sampling Bituminous Materials.

STANDARD DEFINITIONS

D 8 – 18. Of Terms Relating to Materials for Roads and Pavements.

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.

COAL AND COKE

STANDARD SPECIFICATIONS

D 17 – 16. For Foundry Coke.
D 166 – 24. For Gas and Coking Coals.

STANDARD METHODS

*D 21 – 16. Of Sampling Coal.
D 22 – 24. Of Laboratory Sampling and Analysis of Coal.
D 37 – 24. Of Laboratory Sampling and Analysis of Coke.
D 141 – 23. Of Shatter Test for Coke.
D 167 – 24. Of Test for Volume of Cell Space of Lump Coke.

TIMBER AND TIMBER PRESERVATIVES

STANDARD SPECIFICATIONS

D 10 – 15. For Yellow-Pine Bridge and Trestle Timbers.
D 24 – 20. For Southern Yellow-Pine Timber to be Creosoted.
D 25 – 20. For Southern Yellow-Pine Piles and Poles to be Creosoted.
D 52 – 20. For Wooden Paving Blocks for Exposed Pavements.

STANDARD METHODS

D 38 – 24. Of Sampling and Analysis of Creosote Oil.

STANDARD DEFINITIONS

D 9 – 15. Of Terms Relating to Structural Timber.

WATERPROOFING

STANDARD SPECIFICATIONS

D 40 – 25. For Asphalt for Use in Damp-proofing and Waterproofing Below Ground Level.
D 144 – 25. For Asphalt for Use in Damp-proofing and Waterproofing Above Ground Level.
D 41 – 26. For Primer for Use with Asphalt in Damp-proofing and Waterproofing Below and Above Ground Level.
D 42 – 25. For High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level.
D 145 – 25. For High-Carbon Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level.
D 200 – 25. For High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Below Ground Level.
D 201 – 25. For High-Bitumen Coal-Tar Pitch for Use in Damp-proofing and Waterproofing Above Ground Level.
D 43 – 25. For Creosote Oil for Priming Coat with Coal-Tar Pitch in Damp-proofing and Waterproofing Below and Above Ground Level.
D 169 – 25. For Asphalt Mastic for Use in Waterproofing.

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.

D 170 - 25. For Bituminous Grout for Use in Waterproofing Above Ground Level.

D 171 - 25. For Bituminous Grout for Use in Waterproofing Below Ground Level.

D 173 - 25. For Woven Cotton Fabrics Saturated with Bituminous Substances for Use in Waterproofing.

D 174 - 25. For Burlap Saturated with Bituminous Substances for Use in Waterproofing.

INSULATING MATERIALS

STANDARD METHODS

D 48 - 24. Of Testing Molded Insulating Materials.

D 117 - 24. Of Testing Transformer and Switch Oils.

RUBBER PRODUCTS

STANDARD SPECIFICATIONS

D 14 - 23. For Cotton Rubber-Lined Fire Hose for Private Fire Department Use.

D 26 - 23. For Cotton Rubber-Lined Fire Hose for Public Fire Department Use.

D 46 - 24. For Wrapped Air Hose for Use with Pneumatic Tools.

D 60 - 24. For Braided Air Hose for Use with Pneumatic Tools.

D 177 - 24. For Wrapped Cold Water Hose.

D 53 - 24. For Rubber Belting for Power Transmission.

D 120 - 23. For Rubber Gloves for Electric Workers on Apparatus or Circuits Not Exceeding 3000 Volts to Ground.

D 178 - 24. For Rubber Matting for Use Around Electrical Apparatus or Circuits Not Exceeding 3000 Volts to Ground.

D 151 - 23. For Rubber Pump Valves.

D 69 - 24. For Adhesive Tape for General Use for Electrical Purposes.

STANDARD METHODS

D 15 - 24. Of Testing Rubber Products.

TEXTILE MATERIALS

STANDARD SPECIFICATIONS

D 122 - 25. For Imperfections and Tolerances for Square-Woven Tire Fabrics.

D 179 - 25. For Imperfections and Tolerances for Cord Tire Fabrics.

D 181 - 25. For Tolerances for Hose Ducks and Belt Ducks.

D 203 - 25. For Tolerances and Test Methods for Electrical Cotton Yarns.

D 205 - 25. Specifications and Tests for Osnaburg Cement Sacks.

STANDARD METHODS

D 39 - 24. Of Testing Cotton Fabrics.

THERMOMETERS

STANDARD SPECIFICATIONS

D 182 - 25. For A.S.T.M. Partial-Immersion Thermometer for General Use, −20 to +150° C., 0 to +300° F.

D 183 - 25. For A.S.T.M. Partial-Immersion Thermometer for General Use, −5 to +300° C., +20 to +580° F.

D 184 - 25. For A.S.T.M. Partial-Immersion Thermometer for General Use, −5 to +400° C., +20 to +760° F.

E. MISCELLANEOUS SUBJECTS

STANDARD SPECIFICATIONS

E 11 - 26. For Sieves for Testing Purposes.

STANDARD METHODS

E 4 - 24. Of Verification of Testing Machines.

E 3 - 24. Of Metallographic Testing of Iron and Steel.

E 5 - 24. Of Metallographic Testing of Non-Ferrous Metals and Alloys.

STANDARD RULES

E 2 - 24. Governing the Preparation of Micrographs of Metals and Alloys, Including Recommended Practice for Photography as Applied to Metallography.

STANDARD DEFINITIONS

E 7 - 24. Of Terms Relating to Metallography.

LIST OF A. S. T. M. TENTATIVE STANDARDS[1]

As of September 1, 1926. Total Number, 227.

Published Collectively in their latest revised form in 1926 BOOK OF A.S.T.M. TENTATIVE STANDARDS. Tentative Standards are also published in the annual Proceedings, Part I, in the year in which they were submitted or last revised as indicated by the final number of their serial designation.

The term "Tentative Standard" is applied to a proposed Standard which is printed in the Proceedings for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards the adoption of such Tentative Standard by formal action of the Society.

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In the serial designations prefixed to the following titles, the initial letter indicative of the general classification and the first number are permanent, and are retained when a Tentative Standard is adopted as Standard. The final number indicates the year of original issue or, in the case of revision, the year of last revision. In using Tentative Standards, care should be taken to refer to the latest revision which may always be found in the Book of A.S.T.M. Tentative Standards issued yearly about October 1. The letter "T" is appended to the designation of all Tentative Standards. The serial designations of Tentative Standards which have for any reason not been adopted as standard and have been discontinued, are permanently dropped. In ordering Tentative Standards, the complete serial designations should be stated, thus, A 67 - 26 T, etc.

A. FERROUS METALS

STEEL

Tentative Specifications

A 1 - 26 T.	For Open-Hearth Carbon-Steel Rails.[2]
A 2 - 26 T.	For the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types.[3]
A 65 - 26 T.	For Soft Steel Track Spikes.[4]

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[1] For a complete list of standards and tenative standards with serial designations in continuous numeric sequence, see 1926 A.S.T.M. Year Book.

[2] To replace, when adopted, the present Standard Specifications for Carbon-Steel Rails (Serial Designation: A 1 - 24).

[3] To replace, when adopted, the present Standard Specifications for the Manufacture of Open-Hearth Steel Girder Rails of Plain, Grooved and Guard Types (Serial Designation: A 2 - 24).

[4] To replace, when adopted, the present Standard Specifications for Steel Track Spikes (Serial Designation: A 65 - 24).

A 67 – 26 T.	For Steel Tie Plates.
A 76 – 20 T.	For Low-Carbon Steel Track Bolts.
A 77 – 20 T.	For Electric Cast-Steel Anchor Chain.
A 78 – 23 T.	For Steel Plates of Structural Quality for Forge Welding.
A 89 – 23 T.	For Steel Plates of Flange Quality for Forge Welding.
A 82 – 21 T.	For Cold-Drawn Steel Wire for Concrete Reinforcement.
A 87 – 22 T.	For Carbon-Steel Castings for Railroads.
A 21 – 25 T.	For Carbon-Steel Car and Tender Axles.[1]
A 94 – 25 T.	For Structural Silicon Steel.
A 95 – 26 T.	For Carbon-Steel Castings for Valves, Flanges, and Fittings for High-Temperature Service.
A 105 - 26 T.	For Forged or Rolled Steel Pipe Flanges for High-Temperature Service.
A 106 – 26 T.	For Lap-Welded and Seamless Steel Pipe for High-Temperature Service.
A 107 – 26 T.	For Commercial Quality Hot-Rolled Bar Steels.
A 108 – 26 T.	For Commercial Cold-Finished Bar Steels and Cold-Finished Shafting.
A 109 – 26 T.	For Cold-Rolled Strip Steel.
A 93 – 24 T.	For Hot-Dipped Galvanized Sheets.
A 110 – 26 T.	For the Coating on Zinc-Coated (Galvanized) Wire.
A 111 – 26 T.	For Zinc-Coated (Galvanized) Iron or Steel Telephone and Telegraph Line Wire.
A 112 – 26 T.	For Zinc-Coated (Galvanized) Iron or Steel Tie Wires.

Tentative Methods

A 34 – 26 T.	Of Test for Magnetic Properties of Iron and Steel.[2]

Tentative Recommended Practice

A 37 – 25 T.	For Carburizing and Heat Treatment of Carburized Objects.[3]

FERRO-ALLOYS

Tentative Specifications

A 97 – 25 T.	For Tungsten Powder.
A 98 – 25 T.	For Spiegeleisen.
A 99 – 25 T.	For Ferro-Manganese.
A 100 – 25 T.	For Ferro-Silicon.
A 101 – 25 T.	For Ferro-Chromium.
A 102 – 25 T.	For Ferro-Vanadium.

Tentative Methods

A 103 – 25 T.	Of Sampling Ferro-Alloys.
A 104 – 25 T.	Of Chemical Analysis of Ferro-Alloys.

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[1] To replace, when adopted, the present Standard Specifications for Carbon-Steel Car and Tender Axles (Serial Designation: A 21 – 18).

[2] To replace, when adopted, the present Standard Methods of Test for Magnetic Properties of Iron and Steel (Serial Designation: A 34 – 24).

[3] To replace, when adopted, the present Recommended Practice for Heat Treatment of Case-Hardened Carbon-Steel Objects (Serial Designation: A 37 – 14).

WROUGHT IRON

TENTATIVE SPECIFICATIONS

A 86 – 25 T. For Hollow Staybolt Iron.

B. NON-FERROUS METALS

TENTATIVE SPECIFICATIONS

B 51 – 24 T. For Phosphor Tin.
B 52 – 24 T. For Phosphor Copper.
B 53 – 24 T. For Silicon Copper.
B 58 – 26 T. For Aluminum-Base Sand-Casting Alloys in Ingot Form.
B 26 – 26 T. For Aluminum Base Alloy Sand Castings.
B 9 – 26 T. For Bronze Trolley Wire.[1]
B 48 – 26 T. For Soft Rectangular Copper Wire.
B 7 – 24 T. For Manganese-Bronze Ingots for Sand Castings.
B 54 – 24 T. For Manganese-Bronze Sand Castings.
B 59 – 26 T. For Aluminum Bronze Castings.
B 60 – 26 T. For Sand Castings of the Alloy: Copper 88 per cent; Tin 8 per cent; Zinc 4 per cent.
B 61 – 26 T. For Steam or Valve Bronze Sand Castings.
B 62 – 26 T. For Composition Brass or Ounce Metal Sand Castings.
B 57 – 25 T. For Muntz Metal Condenser Tube Plates.
B 17 – 21 T. For Non-Ferrous Alloys for Railway Equipment in Ingots, Castings, and Finished Car and Tender Bearings.
B 24 – 26 T. For Aluminum Ingots for Remelting.
B 25 – 26 T. For Aluminum Sheet.
B 50 – 25 T. For Non-Ferrous Insect Screen Cloth.

TENTATIVE METHODS

B 40 – 26 T. Of Chemical Analysis of Aluminum and Light Aluminum Alloys.
B 63 – 26 T. Of Test for Resistivity of Metallic Materials for Electric Heating.

C. CEMENT, LIME, GYPSUM, AND CLAY PRODUCTS

TENTATIVE SPECIFICATIONS

C 9 – 16 T. Specifications and Tests for Compressive Strength of Portland-Cement Mortars.[2]
C 15 – 17 T. For Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling.
C 46 – 25 T. For Quicklime for Use in the Manufacture of Sulfite Pulp.

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[1] To replace, when adopted, the present Standard Specifications for High-Strength Bronze Trolley Wire, Round and Grooved: 40 and 65-per-cent Conductivity (Serial Designation: B 9 – 16).

[2] To be added, when adopted, to the Standard Specifications and Tests for Portland Cement (Serial Designation: C 9 – 26).

C 47 - 22 T.	For Hydrated Lime for the Manufacture of Varnish.
C 53 - 25 T.	For Quicklime for Use in Water Treatment.
C 54 - 25 T.	For Hydrated Lime for Use in Water Treatment.
C 33 - 26 T.	For Concrete Aggregates.
C 55 - 24 T.	For Concrete Building Brick.
C 59 - 26 T.	For Gypsum Molding Plaster.
C 60 - 26 T.	For Gypsum Pottery Plaster.
C 61 - 26 T.	For Keene's Cement.
C 56 - 26 T.	Specifications and Tests for Hollow Burned-Clay Fireproofing, Partition and Furring Tile.
C 57 - 26 T.	Specifications and Tests for Hollow Burned-Clay Floor Tile.
*C 19 - 26 T.	For Fire Tests of Building Construction and Materials.

TENTATIVE METHODS

C 25 - 26 T.	Of Chemical Analysis of Limestone, Quicklime and Hydrated Lime.
C 50 - 24 T.	Of Sampling, Inspection, Packing and Marking of Quicklime and Lime Products.
C 38 - 26 T.	Of Test for Resistance of Fire-Clay Brick to Spalling Action.
C 42 - 25 T.	Of Securing Specimens of Hardened Concrete from the Structure.

TENTATIVE DEFINITIONS

C 51 - 24 T.	Of Terms Relating to Lime.
C 11 - 26 T.	Of Terms Relating to the Gypsum Industry.[1]
C 58 - 26 T.	Of the Terms Sand and Aggregate.

TENTATIVE RULES

C 44 - 22 T.	For Inspection of Concrete and Reinforced Concrete Work.

D. MISCELLANEOUS MATERIALS

PRESERVATIVE COATINGS

TENTATIVE SPECIFICATIONS

D 12 - 25 T.	For Raw Tung Oil.
D 124 - 22 T.	For Soya Bean Oil, Raw or Refined.
D 234 - 26 T.	For Raw Linseed Oil.
D 78 - 21 T.	For Purity of Boiled Linseed Oil from South American Seed.
D 235 - 26 T.	For Petroleum Spirits (Mineral Spirits).
D 236 - 26 T.	For Destructively Distilled Wood Turpentine.
D 237 - 26 T.	For Orange Shellac.
D 84 - 25 T.	For Iron Oxide and Iron Hydroxide.
D 211 - 26 T.	For Chrome Yellow.
D 212 - 26 T.	For Pure Chrome Green.
D 213 - 26 T.	For Reduced Chrome Green.

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* Approved as "Tentative American Standard" by the American Engineering Standards Committee.

[1] To be added, when adopted, to the present Standard Definitions of Terms Relating to the Gypsum Industry (Serial Designation: C 11 - 26).

TENTATIVE METHODS

D 214 – 26 T. Of Testing Shellac Varnish.
D 238 – 26 T. Of Test for Specific Gravity of Pigments.
D 154 – 26 T. Of Test for Elasticity or Toughness of Varnishes by Means of Addition of Linseed Oil.[1]
D 215 – 25 T. Of Routine Analysis of White Linseed Oil Paints.

PETROLEUM PRODUCTS AND LUBRICANTS

TENTATIVE METHODS

D 86 – 26 T. Of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products.
D 216 – 25 T. Of Test for Distillation of Natural Gas Gasoline.
D 127 – 24 T. Of Test for Melting Point of Petrolatum.
D 128 – 26 T. Of Analysis of Grease.
D 217 – 26 T. Of Test for Penetration of Greases.
D 155 – 23 T. Of Test for Color of Lubricating Oils by Means of Union Colorimeter.
D 218 – 25 T. Of Test for Color of Petrolatum by Means of the Union Colorimeter.
D 156 – 23 T. Of Test for Color of Refined Petroleum Oil by Means of Saybolt Chromometer.
D 187 – 24 T. Of Test for Burning Quality of Kerosine Oils.
D 219 – 26 T. Of Test for Burning Quality of Long-Time Burning Oil for Railway Use.
D 239 – 26 T. Of Test for Burning Quality of Mineral Colza Oil.
D 90 – 26 T. Of Test for Sulfur in Naphthas and Illuminating Oils.
D 129 – 22 T. Of Test for Sulfur in Petroleum Oils Heavier than Illuminating Oil.
D 130 – 22 T. Of Test for Detection of Free Sulfur and Corrosive Sulfur Compounds in Gasoline.
D 91 – 21 T. Of Test for Precipitation Number of Lubricating Oils.
D 157 – 23 T. Of Test for Steam Emulsion of Lubricating Oils.
D 94 – 21 T. Of Test for Saponification Number.
D 188 – 26 T. Of Test for Neutralization Number of Petroleum Products and Lubricants.
D 189 – 24 T. Of Test for Carbon Residue of Lubricants.
D 97 – 25 T. Of Test for Cloud and Pour Points of Petroleum Products.
D 158 – 25 T. Of Testing Gas Oils (Gravity, Distillation, Sulfur, Carbon Residue, Pour Point, Viscosity, Water).
D 240 – 26 T. Of Test for Thermal Value of Fuel Oil.

ROAD MATERIALS

TENTATIVE SPECIFICATIONS

D 63 – 23 T. For Commercial Sizes of Broken Stone and Broken Slag for Highway Construction.
D 64 – 20 T. For Commercial Sizes of Sand and Gravel for Highway Construction.

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[1] To be added, when adopted, to the present Standard Methods of Testing Oleo-Resinous Varnishes (Serial Designation: D 154 – 24).

D 190 – 24 T.	For Broken Stone for Waterbound Base.
D 191 – 24 T.	For Broken Stone for Waterbound Macadam Surface Course.
D 192 – 24 T.	For Broken Stone for Bituminous Macadam.
D 193 – 24 T.	For Broken Stone for Bituminous Concrete Base.
D 194 – 24 T.	For Broken Stone for Bituminous Concrete Surface.
D 195 – 24 T.	For Broken Slag for Bituminous Macadam Base.
D 196 – 24 T.	For Broken Slag for Bituminous Concrete Base.
D 159 – 24 T.	For Broken Slag for Bituminous Macadam Wearing Course.
D 160 – 24 T.	For Broken Slag for Bituminous Concrete (Coarse-Graded Aggregate Type).
D 161 – 24 T.	For Broken Slag for Bituminous Concrete (Fine-Graded Aggregate Type.
D 162 – 23 T.	For Sand for Sheet Asphalt and Bituminous Concrete Pavements.
D 67 – 23 T.	For Natural or Artificial Sand-Clay Mixtures for Road Surfacing.
D 98 – 22 T.	For Calcium Chloride for Dust Prevention.
D 133 – 23 T.	For Asphalt Cement, 10 to 15 Penetration, for the Manufacture of Asphalt Block.
D 134 – 23 T.	For Asphalt Cement, 15 to 25 Penetration, for the Manufacture of Asphalt Block.
D 163 – 23 T.	For Asphalt Cement, 25 to 30 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements.
D 164 – 23 T.	For Asphalt Cement, 30 to 40 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements.
D 99 – 26 T.	For Asphalt Cement, 40 to 50 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements and as Filler for Brick and Block Pavements.
D 100 – 26 T.	For Asphalt Cement, 50 to 60 Penetration, for Use in Sheet Asphalt and Asphaltic Concrete Pavements and as Filler for Block Pavements.
D 101 – 26 T.	For Asphalt Cement, 60 to 70 Penetration, for Use in Sheet Asphalt, Asphaltic Concrete, and Asphalt Macadam Pavements and as Filler for Block Pavements.
D 102 – 24 T.	For Asphalt Cement, 85 to 100 Penetration, for Use in Asphalt Macadam Pavements.
D 103 – 24 T.	For Asphalt Cement, 100 to 120 Penetration, for Use in Asphalt Macadam Pavements.
D 135 – 23 T.	For Asphalt Cement, 120 to 150 Penetration, for Use in Asphalt Macadam Pavements.
D 104 – 23 T.	For High-Carbon Tar for Surface Treatment, Cold Application.
D 105 – 23 T.	For Low-Carbon Tar for Surface Treatment, Cold Application.
D 106 – 25 T.	For High-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product).
D 107 – 23 T.	For Low-Carbon Tar Cement for Use Cold in Repair Work (Cut-Back Product).
D 108 – 23 T.	For High-Carbon Tar for Surface Treatment, Hot Application.
D 109 – 23 T.	For Low-Carbon Tar for Surface Treatment, Hot Application.
D 110 – 25 T.	For High-Carbon Tar Cement.
D 111 – 23 T.	For Low-Carbon Tar Cement.

D 112 - 23 T.	For Coal-Tar Pitch for Stone Block Filler.
D 241 - 26 T.	For Asphalt Filler for Brick Pavements (Blown Type).
D 242 - 26 T.	For Mineral Filler for Sheet Asphalt and Bituminous Concrete Pavements.

TENTATIVE METHODS

D 70 - 26 T.	Of Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cement and Soft Tar Pitches.
D 71 - 26 T.	Of Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments.
D 73 - 20 T.	Of Test for Quantity of Clay in Sand-Clay, Topsoil and Semi-Gravel for Highway Construction.
D 136 - 22 T.	Of Decantation Test for Sand and Other Fine Aggregates.
D 220 - 25 T.	Of Test for the Determination of Moisture Equivalent of Subgrade Soils in the Field.
D 138 - 26 T.	Of Test for Consistency of Portland-Cement Concrete.
D 4 - 26 T.	Of Test for the Determination of Bitumen.
D 165 - 26 T.	Of Test for the Determination of Proportion of Bitumen Soluble in Carbon Tetrachloride.
D 20 - 26 T.	Of Test for Distillation of Bituminous Materials Suitable for Road Treatment.
D 113 - 26 T.	Of Test for Ductility of Bituminous Materials.
D 139 - 25 T.	Of Float Test for Bituminous Materials.
D 243 - 26 T.	Of Test for Residue of Specified Penetration.
D 244 - 26 T.	Of Testing Bituminous Emulsions.

COAL AND COKE

TENTATIVE METHOD

D 197 - 26 T.	Of Test for Fineness of Powdered Coal.

TENTATIVE DEFINITIONS

D 121 - 26 T.	Of Terms Relating to Coal and Coke.

TIMBER

TENTATIVE SPECIFICATIONS

D 245 - 26 T.	For Structural Joist, Planks, Beams, Stringers and Posts.

TENTATIVE METHODS

D 143 - 24 T.	Of Testing Small Clear Specimens of Timber.
D 198 - 24 T.	For Conducting Static Tests of Timber in Structural Sizes.
D 168 - 23 T.	Of Test for Coke Residue of Creosote Oil.[1]
D 246 - 26 T.	Of Test for Distillation of Creosote Oil.[1]
D 199 - 24 T.	Of Chemical Analysis of Zinc Chloride.

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[1] To be added, when adopted, to the present Standard Methods of Sampling and Analysis of Creosote Oil (Serial Designation: D 38 - 24).

SHIPPING CONTAINERS

TENTATIVE SPECIFICATIONS

D 44 – 20 T.	For Wooden Boxes, Nailed and Lock-Corner Construction, for the Shipment of Canned Foods.
D 45 – 17 T.	For Canned Foods Boxes, Wirebound Construction.
D 68 – 22 T.	For Wooden Boxes, Nailed and Lock-Corner Construction.
D 118 – 21 T.	For 4-One Boxes and Similar Type Boxes.

WATERPROOFING AND ROOFING

TENTATIVE SPECIFICATIONS

D 223 – 25 T.	For Acid Resisting Asphalt Mastic.
D 224 – 26 T.	For Asphalt Roll-Roofing Surfaced with Powdered Talc.
D 225 – 26 T.	For Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles.
D 248 – 26 T.	For Asphalt Roll-Roofing Surfaced with Granular Talc.
D 249 – 26 T.	For Heavy Weight Slate-Surfaced Asphalt Roll-Roofing and Heavy Weight Slate-Surfaced Asphalt Shingles.
D 226 – 26 T.	For Asphalt-Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs.
D 227 – 26 T.	For Coal-Tar Saturated Roofing Felt for Use in Waterproofing and in Constructing Built-Up Roofs.
D 250 – 26 T.	For Asphalt-Saturated Asbestos Felt for Use in Constructing Built-Up Roofs.
D 251 – 26 T.	For High-Carbon Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel.
D 252 – 26 T.	For High-Bitumen Coal-Tar Pitch for Use in Constructing Built-Up Roofs Surfaced with Slag or Gravel.
D 253 – 26 T.	For Light Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-proofing Masonry Structures.
D 254 – 26 T.	Heavy Body Coal-Tar or Water-Gas-Tar Protective Coating with Solvent Vehicle, for Cold Application, for Damp-proofing Masonry Structures.

TENTATIVE METHODS

D 146 – 26 T.	Of Testing Felted and Woven Fabrics Saturated with Bituminous Substances for Use in Waterproofing and Roofing.
D 147 – 25 T.	Of Testing Bituminous Mastics, Grouts and Like Mixtures.
D 228 – 26 T.	Of Testing Asphalt Roll-Roofing Surfaced with Fine or Granular Talc, Slate-Surfaced Asphalt Roll-Roofing and Slate-Surfaced Asphalt Shingles.
D 255 – 26 T.	Of Test for Steam Distillation of Bituminous Protective Coatings.

SLATE

TENTATIVE METHODS

D 221 - 25 T.	Of Test for Water Absorption of Slate.
D 222 - 25 T.	Of Flexure Testing of Slate.

TENTATIVE DEFINITION

D 247 - 26 T.	Of the Term Slate.

INSULATING MATERIALS

TENTATIVE METHODS

D 115 - 26 T.	Of Testing Insulating Varnishes.
D 116 - 26 T.	Of Testing Electrical Porcelain.
D 117 - 26 T.	Of Testing Electrical Insulating Oils.[1]
D 149 - 26 T.	Of Testing Sheet and Tape Insulating Materials for Dielectric Strength.
D 150 - 23 T.	Of Testing Electrical Insulating Materials for Phase Difference (Power Factor) and Dielectric Constant at Radio Frequencies.
D 175 - 25 T.	Of Testing Electrical Insulating Materials for Voltage Effects at Radio Frequencies.
D 176 - 25 T.	Of Testing Cable Splicing and Pothead Compounds.
D 202 - 26 T.	Of Testing Untreated Insulating Paper.
D 229 - 26 T.	Of Testing Laminated Sheet Insulating Materials.
D 256 - 26 T.	Of Testing Insulating Materials for Resistance to Impact.
D 257 - 26 T.	Of Test for Surface Resistivity and Volume Resistivity of Solid Insulating Materials.

RUBBER PRODUCTS

TENTATIVE SPECIFICATIONS

D 27 - 21 T.	For Insulated Wire and Cable: 30-per-cent Hevea Rubber.
D 54 - 24 T.	For Steam Hose.
D 119 - 22 T.	For Rubber Insulating Tape.

TEXTILE MATERIALS

TENTATIVE SPECIFICATIONS

D 76 - 25 T.	For Textile Testing Machines.
D 180 - 25 T.	For Tolerances and Test Methods for Cotton Yarns, Single and Plied.
D 258 - 26 T.	For Tolerances and Test Methods for Rayon.
D 204 - 25 T.	For Tolerances and Test Methods for Cotton Sewing Threads.
D 230 - 25 T.	For Tolerances for Numbered Cotton Duck.
D 231 - 25 T.	For Tolerances and Test Methods for Knit Goods.
D 259 - 26 T.	For Tolerances and Test Methods for Electrical Silk and Cotton Tapes.

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[1] To replace, when adopted, the present Standard Methods of Testing Transformer and Switch Oils (Serial Designation: D 117 - 24).

TENTATIVE METHODS

D 152 - 22 T.	Of Testing Cotton Fibers.
D 232 - 25 T.	Of Testing Grease Wool and Allied Fibers for Scoured Content.

TENTATIVE DEFINITIONS

D 123 - 26 T.	Of Terms Relating to Textile Materials.

E. MISCELLANEOUS SUBJECTS

TENTATIVE METHODS

E 8 - 25 T.	Of Tension Testing of Metallic Materials.
E 9 - 25 T.	Of Compression Testing of Metallic Materials.
E 10 - 25 T.	Of Brinell Hardness Testing of Metallic Materials.
E 4 - 26 T.	Of Verification of Testing Machines by Means of an Elastic Calibration Bar.[1]

TENTATIVE DEFINITIONS

E 6 - 25 T.	Of Terms Relating to Methods of Testing.
E 12 - 26 T.	Of Terms Relating to Specific Gravity.
E 13 - 26 T.	Of the Term Screen (Sieve).
E 7 - 26 T.	Of the Term Metallography.[2]

TENTATIVE RECOMMENDED PRACTICE

E 14 - 25 T.	For Thermal Analysis of Steel.
E 15 - 26 T.	For Radiographic Testing of Metal Castings.
E 2 - 26 T.	For the Care of the Eyes When Using a Metallographic Microscope.[3]

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[1] To be added, when adopted, to the present Standard Methods of Verification of Testing Machines (Serial Designation: E 4 - 24).

[2] To be added, when adopted, to the present Standard Definitions of Terms Relating to Metallography (Serial Designation: E 7 - 24).

[3] To be added, when adopted, as an appendix to the Recommended Practice for Photography as Applied to Metallography, appearing in the Standard Rules Governing the Preparation of Micrographs of Metals and Alloys (Serial Designation: E 2 - 24).